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Central Heating Plant Economic Evaluation Program, Volume 2: User's Manual

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This five-volume report discusses the Central Heating Plant Economic Evaluation Program (CHPECON), a computer program for screening potential new and retrofit steam/power generation facilities.

Volume 1 is the Technical Reference.
Volume 2 is the User's Manual.
Volume 3 is the Military Base Weather Information Data Management Program.
Volume 4 is the Coalfield Properties Information Data Management Program.
Volume 5 is the Emission Regulations Data Management Program.

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The program provides sufficient flexibility to vary critical design and operating parameters to determine project sensitivity and parametric evaluation.

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Foreword

This study was conducted for the Assistant Chief of Staff for Installation Management (ACS(IM)), Directorate of Facilities and Housing under the Coal Conversion Studies Program, which is administered by the Energy Policy Directorate of the Office of the Assistant Secretary of Defense, Production & Logistics, Energy Policy (OASD P&L/EP). Millard Carr is the Program Manager. Funding was provided under Military Interdepartmental Purchase Request (MIPR) No. W56HZV89-AC-01; Work Units "Coal Conversion Strategies for DOD" and "Enhancement of Existing Models," dated 20 November 1989. The technical monitor was Qaiser Toor, DAIM-FDF-U.

The work was performed by the Fuels and Power Systems Team (FEP), Energy and Utility Systems Division (FE) of the Infrastructure Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). Special acknowledgement is given to Lee Thurber, Rama Katz, and Mei-Yi Feng, CECER-FE for their efforts in organizing technical materials. Dr. David M. Joncich is Chief, CECER-FE, and Alan Moore is Acting Chief, CECER-FL. The USACERL technical editor was Gloria J. Wienke, Information Management Office.

LTC David J. Rehbein is Commander and Acting Director, USACERL. Dr. Michael J. O'Connor is Technical Director.

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1 Introduction

Background

The fiscal year (FY) 1986 Defense Appropriation Act (Public Law [PL] 99-190 Section 8110) directed the Department of Defense (DOD) to implement the rehabilitation and conversion of central heating plants to coal firing. The target set by this act was 1.6 million short tons* of coal per year above the 1985 consumption level by 1994. The language further stated that 300,000 tons of this amount should be anthracite coal. The purpose of this Section was to offset decreasing anthracite coal use in Germany resulting from U.S. Army, Europe (USAREUR) installations connecting to district heating systems. The FY 1987 Defense Authorization Act (PL-99-661, Section 1205) also directed that the primary fuel source in any new heating system be the most life cycle cost effective. To assist in complying with these acts, the U.S. Army Center for Public Works (USACPW) requested that the U.S. Army Construction Engineering Research Laboratories (USACERL) provide technical studies and support for the Army's Coal Conversion Program.

Objective

The objective of this project is to develop a series of screening and life cycle cost estimating computer models to determine when and where specific coal combustion technologies can be economically implemented at Army central heating plants.

Approach

The approach for providing Coal Conversion Program support has been to develop tools useful for long range utility planning and for evaluating both the technical and economic feasibility of conversion. Cost estimating methods have been developed for building new coal, gas, or oil plants, and for retrofitting existing plants to coal firing capability. Supporting databases have been developed covering installation-specific data (heating plant inventory, building inventory, weather data, energy usage),

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* A metric conversion table is on page 149.

environmental regulations, coal supply information, and combustion equipment performance. The plant sizes examined in the model range from 50,000 to 600,000 pounds per hour (lb/hr) with individual boiler sizes from 20,000 to 200,000 lb/hr of steam or high temperature hot water (HTHW). The program is divided into two parts: the preliminary screening model and the detailed cost model. The screening model is used to initially evaluate each plant site and boiler technology option to produce a list of the promising locations and technology options. The screening model contains five distinct sections for evaluating new heating plants, retrofit heating plants, cogeneration facilities (in base-managed and third-party-managed forms), and consolidation of existing multiple boiler plants.

The new heating plant screening model is used to determine if a new coal-fired heating plant can be built to replace an existing steam plant (150 pounds per square inch gauge [psig] saturated steam or equivalent hot water or 250 psig saturated steam). The boiler technology options include: stoker, bubbling fluidized bed, circulating fluidized bed, coal/water slurry, coal/oil slurry, natural gas, and #2 and #6 fuel oils.

The retrofit screening model is used to determine if the existing boilers can be retrofitted to fire coal or low-British thermal unit (Btu) gas supplied from a gasifier. The boiler options include: coal-water slurry, coal-oil slurry, micronized coal, slagging coal, bubbling fluidized bed, and stoker, as well as gasification.

The cogeneration screening model is used to determine if a new cogeneration steam plant is a feasible alternative for a military base heating plant. Medium pressure (600 psig, 750 °F) or high pressure (1300 psig, 1000 °F) plants can be analyzed. The boiler types considered are stoker, coal-oil slurry, coal-water slurry, bubbling fluidized bed, and circulating fluidized bed.

The consolidation screening model is used to determine if the military base should consolidate several individual heating plants into one main heating plant. This section assesses whether the steam distribution density is sufficient to consider consolidation as a practical option.

After the screening model has been executed, the user has the option to quit or to restart another screening model (for another option) or to continue to obtain a cost estimate for the selected facility. The costing model contains sections for a new heating plant, retrofit heating plant, cogeneration facility (base and third party), and consolidated facility.

The costing model provides conceptual facility design, capital installed costs of the conceptual facility, operational and maintenance costs over the life of the conceptual facility, and life cycle costs.

CHPECON is structured into the seven main types of operations: screening, costing, multiple run analysis, sensitivity analysis, load sensitivity analysis, data base updating, and system utilities. These operations are discussed in Chapters 3 through 9.

Report Organization

This report reference discusses the Central Heating Plant Economic Evaluation Program (CHPECON) and is divided into the following five volumes:

Central Heating Plant Economic Avaluation Program, Volume 1: Technical Reference.

Central Heating Plant Economic Avaluation Program, Volume 2: User's Manual.

Central Heating Plant Economic Avaluation Program, Volume 3: Military Base Weather Information Data Management Program.

Central Heating Plant Economic Avaluation Program, Volume 4: Coalfield Properties Information Data Management Program.

Central Heating Plant Economic Avaluation Program, Volume 5: Emission Regulations Data Management Program.

System Requirements

CHPECON was developed using an 80286 personal computer with 640K memory, and was run using MS-DOS 3.3. The models should operate satisfactorily on 8088/80286/80386 processors with MS-DOS 2.0 and above. The program is written in dBase III Plus* compatible language with some extensions. To provide the necessary speed and compactness, the program is distributed in compiled form using Nantucket's Clipper** and allows stand-alone operation without requiring additional utilities.

* dBASE III Plus is a registered trademark of Ashton-Tate.

** Clipper is a registered trademark of Nantucket Software.

Scope

The purpose of this work is to investigate the feasibility of converting Army central heating plants to coal firing. The models developed are generally applicable to industrial or large commercial size facilities. The economic evaluation program for screening and life cycle costs will serve as a tool to select and rank potential Army sites for coal conversion.

Mode of Technology Transfer

The CHPECON program may be obtained by contacting the USACERL Fuels and Power Systems Team at 1-800-872-2375, extension 5551. The program will be transferred to Major Army Command Headquarters for further distribution. It is recommended that availability of this program and the information presented in this report be disseminated in a Public Works Technical Bulletin.

2 Installation and Operation

The 99 CHPECON program and data files are compressed and stored in two executable files named CH921216.exe (943547 Bytes) and CHPDBF.exe (641272 Bytes). The files are on two 5.25-in., 1.2 M double sided, high density floppy disks (or two 3.5-in., 1.4M).

To install CHPECON:

1. Select the disk drive (or partition) where CHPECON will be installed, by entering the command **C**: and pressing <ENTER>.*

2. Create a subdirectory to hold CHPECON (a subdirectory is recommended to increase operating speed and not limit the program in the number of files it can use) by entering the command **MD\CHPECON** and pressing <ENTER>. (CHPECON is used as an example, although you can select another DOS-acceptable name if desired).

3. Change to the directory for CHPECON by entering the command **CD\CHPECON** and pressing <ENTER>.

4. Put floppy disk #1 into the high density drive and enter the command **A:\CH921216** and press <ENTER>. Substitute the appropriate drive letter if the high density drive is not A:.

5. Put floppy disk #2 into the high density drive and enter the command **A:\CHPDBF** and press <ENTER>. Substitute the appropriate drive letter if the high density drive is not A:.

After step 5 is completed, the program and data files have been installed. When CHPECON is first run, it will create the indexes for the database files that it needs to operate.

---

* The key completing a command and telling the computer to proceed is usually marked Enter or Return on the keyboard, and is represented by <ENTER> in this manual.

The program in its distributed form is set up to operate using a minimum configuration (monochrome monitor and 80-column printer). If you have a color monitor or a printer that can print at other than 10 characters per inch, select the System Utilities option to modify the screen colors and top/bottom/left margins for printing.

Start the program by changing the computer's default drive and directory to those containing the program, and entering the program name.

1. Select the disk drive where CHPECON is installed, by entering **C**: and pressing <ENTER>. Substitute the correct drive name in place of C:, if necessary.

2. Change to the directory for CHPECON by entering **CD\CHPECON** and pressing <ENTER>. Substitute the correct directory name if necessary.

3. Start the program by entering the program name **CHPECON** and pressing <ENTER>.

When CHPECON starts, it displays the screen shown in Figure 1 (including the version date). The program will wait until you press a key or 5 seconds lapse before showing the second screen (Figure 2). This screen contains a general statement about the purpose of the program and a disclaimer/message.

As CHPECON is starting, it checks for the presence of the database files necessary for its operation. If one or more are not found, CHPECON informs you that they are missing and that the program cannot continue until they are present. CHPECON then stops and returns to the operating system.

If the necessary database files are found, CHPECON checks for the presence of the index files associated with the database files. If one or more of the index files are missing, CHPECON creates them. Once the indexing is completed, or if the files were all found, CHPECON proceeds to the main menu.

The main menu of CHPECON is shown in Figure 3. The eight available options are assigned either a number or a letter. Select a menu option by entering the character representing the option. The program will automatically reject any inappropriate response. The option menus throughout the program operate in a similar manner.

Enter “Q” at the prompt to select quit (exit the program and return to the operating system). Because the program takes some time to load and to check for the presence of the required files, it asks you to confirm the request to quit. If you do not confirm,

the program returns to the menu prompt. This type of confirmation step appears only when completing an action that takes some time or causes an irretrievable loss of data.

If you select any of the other seven options, the program will switch to the menu for that option. Each option is described in more detail in the following chapters.

CHPECON

Central Heating Plant Economics Evaluation Program

Developed by: Institute of Gas Technology

For: U.S. Army Corps of Engineers
Construction Engineering Research Laboratory

December 8, 1992

Press any key to continue...

Figure 1. CHPECON startup screen.

This package was developed for U.S. Army Engineering organizations for use in the development of economic analyses in support of Army funding requests.

This program is furnished by the Government and is accepted and used by the recipient with the express understanding that the United States Government makes no warranties, expressed or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the United States shall be under no liability whatsoever to any person by reason of use made thereof.

The program belongs to the Government. Therefore, the recipient further agrees not to assert any proprietary rights therein or to represent this program to anyone as other than a Government program.

Press any key to continue...

Figure 2. CHPECON disclaimer screen.

Central Heating Plant Economics Evaluation Program
11/19/92
Main Menu

1 -- Screening Models
2 -- Cost Models
3 -- Multiple Run Analysis
4 -- Sensitivity Analysis
5 -- Load Sensitivity Analysis
6 -- Update Databases
7 -- System Utilities
Q -- Quit (exit program)

Use ↑↓ to move highlight or enter first character to select option

Determine a base's general suitability for a coal-fired or oil/gas boiler plant

Figure 3. CHPECON main menu.

3 Screening Model Operation

The menus for the screening model are displayed in two tiers. The first tier is displayed upon entering the option as shown in Figure 4. It lists the five case types you can consider: a new plant, a new plant with cogeneration, a new plant with third-party cogeneration, a new plant with consolidation, and a retrofit plant. If you quit from this tier, the program returns to the CHPECON main menu.

```
Central Heating Plant Economics Evaluation Program 11/19/92
Main menu — screening model

1 -- New plant

2 -- New plant with cogeneration

3 -- New plant with third-party cogeneration

4 -- New plant with consolidation

5 -- Retrofit plant

Q -- Quit (return to main menu)

Use ↑ ↓ to move highlight or enter first character to select option

New boiler plant screening case for heating and process loads
```

Figure 4. Menu display for the screening model - Tier 1 (case types).

After you select the type of case to consider, the program displays the second tier of options as shown in Figure 5. These options are the actions that can be accomplished for each case. The header box shows the case type selected on the first tier of options under the current date in the upper right corner of the screen.

```
Central Heating Plant Economics Evaluation Program   11/19/92
Case menu — screening model  ——————New plant (NP)

                    1 -- Create new case

                    2 -- Use existing case

                    3 -- Delete existing case from storage

                    4 -- Print case study

                    Q -- Quit (return to screening model menu)

Use ↑ ↓ to move highlight or enter first character to select option
-----------------------------------------------------------------------
     Produce a new screening model evaluation
```

Figure 5. Menu display for the screening model - Tier 2 (operation).

If you quit from this tier, the program returns to the first tier. However, if you select one of the four numbered options, the program immediately switches to that operation. Each option is described in the following paragraphs.

Screening Model Option 1: Create New Case

Program Selections

If you select the option to create a new case, the program will display a list of the currently available case files as shown in Figure 6. The program then asks for a new file name. The display contains three columns. The first column is the name of the file. The second column is a two-letter code that matches the type of case in the file. The code NP represents a new plant; CG represents a new plant with cogeneration; TP represents a new plant with third-party cogeneration; CN represents a new plant with consolidation; and RT represents a retrofit plant. The third column is a specific description of the case in the file. It gives the name of the base that was being studied.

File	CT	Case description
CFB1	NP	Picatinny Arsenal
CFB2	CN	Fort Sheridan / Haley AAF
ER1	NP	Fort Sheridan / Haley AAF
ER9	NP	Fort Sheridan / Haley AAF
JAK1	NP	Fort Sheridan / Haley
JAK14	NP	Fort Sheridan / Haley AAF
JAK2	CG	Fort Sheridan / Haley AAF
JAK3	NP	Fort Sheridan / Haley AAF
NP-13	NP	Fort Sheridan / Haley AAF
PICACG	CG	Picatinny Arsenal
PICANP	NP	Picatinny Arsenal
PICANP2	NP	Picatinny Arsenal
RT-1	RT	Fort Sheridan / Haley AAF

Enter file name to use:
(must be new)

? to list more files or blanks to quit

Figure 6. List of current case files.

The file name you enter must be unique; a name not in use as a case file, and not in use for any other purpose. CHPECON checks the entries in the case list entries file, and then checks for the existence of a database file in use for another purpose. If the proposed name is not acceptable due to duplication, the program prompts you for another name. A maximum of eight characters can be used for the file name consisting of the numbers "0" through "9", the letters "A" through "Z", and the character "-".

If you want to return to the menu, leave the name blank by entering spaces; the program understands this as a request to return. If more files are present than can be seen at one time, enter a "?" as the file name to display successive pages. After the program accepts the file name, it continues on to the base selection procedure.

To limit the total number of bases to review during the selection process, CHPECON asks for the state that the base is in. Enter either the standard two letter abbreviation or the full name. If the program cannot determine the state directly, it drops characters off the end until it finds an approximate match or matches. It either accepts the match, or if there is more than one, lists the matches and asks for clarification. Once an acceptable state is entered, it proceeds to the base selection.

Select a particular base by using the cursor keys to move the light bar so that the desired base is highlighted. See Figure 7 for an example of the display. Then press <ENTER> to proceed. If a particular state has more bases than can be seen on one screen, the screen shows a short menu to allow you to move forward and backward through the pages. After moving to the page that has the desired base, enter "S" to tell the program to switch to the selection of bases using the cursor keys.

ST	Latit	Longit	Base Name
IL	42°13'	87°49'	Fort Sheridan / Haley AAF
IL	38°41'	90°11'	St. Louis Area Support Center, Granite City
IL	41°31'	90°33'	Rock Island Arsenal
IL	42°11'	90°15'	Savanna Army Depot
IL	41°31'	88° 4'	Joliet Army Ammunition Plant

↑↓ to select base, <ENTER> to accept

Figure 7. Military base selection display.

After selecting the base, CHPECON determines if the state is divided into smaller pollution regulation areas. If it is, select the appropriate region (or optionally, just the state regulations) in the same manner as you selected the base (see Figure 8). Once the base is selected, the system retrieves the degree day weather factors for that site.

Region	Description
	--- entire state ---
1	Cook County

↑↓ to select region, <ENTER> to accept

Figure 8. Emission regulation region selection.

As shown in Figure 9, CHPECON then presents information about the next section. It also presents the option to quit early and abandon the analysis up to that point. CHPECON next asks for the type of system being used—steam or high temperature hot water (HTHW). Note that this step is skipped when cogeneration is considered,

as the choice must be steam. As shown in Figure 10, the program then asks for the average steam or HTHW load for each month, and for a process load if the system is steam-based. The units for the inputs vary based on the type of system; in thousand pounds of steam per hour for average monthly steam flow, or in million Btus per hour for average monthly HTHW load.

```
          Average monthly steam flows or hot water heating loads
          and any process loads for the base are needed to
          estimate the required plant maximum continuous rating.

Press any key to continue...
(or <Esc> to return to main menu, and delete current case)
```

Figure 9. Display of the notice of an upcoming section and an opportunity to quit.

Based on these values, the program calculates the plant maximum continuous rating (PMCR), which should meet all loads in the worst weather conditions. CHPECON reports this value and gives you a chance to modify the entries. Indicate that the entries are acceptable by answering “no” (“N”) to more changes.

The boiler technology is selected next. Before this section, another notice appears giving you the chance to quit, return to the menu and abandon the work. If you continue, the display shown in Figure 11 appears. After accepting the number input, the program displays the selected technology at the bottom of the screen and asks for confirmation. A different set of boiler technologies is presented if a retrofit case is being studied.

```
Enter the process load (unrelated to heating) that the plant will experience:  0 million Btu/hr
          (or 0 if there is no process load)
Enter average monthly steam flows in thousand lbs/hr
                          AMSF          PMCR
          Jan             155           225
          Feb             148           223
          Mar             117           229
          Apr             84            228
          May             40            224
          Jun             31            225
          Jul             30            220
          Aug             28            223
          Sep             42            226
          Oct             53            229
          Nov             105           227
          Dec             120           224
Selected PMCR:  230 thousand lb steam/hr
Accept these values? (Y/N)
```

Figure 10. Average load input screen.

1	Dump Grate Spreader Stoker, w/ fly ash reinjection
2	Dump Grate Spreader Stoker, w/o fly ash reinjection
3	Vibrating Grate Spreader Stoker, w/ fly ash reinjection
4	Vibrating Grate Spreader Stoker, w/o fly ash reinjection
5	Reciprocating Grate Spreader Stoker, w/ fly ash reinjection
6	Reciprocating Grate Spreader Stoker, w/o fly ash reinjection
7	Traveling Grate Spreader Stoker, w/ fly ash reinjection
8	Traveling Grate Spreader Stoker, w/o fly ash reinjection
9	Traveling Grate Stoker
10	Chain Grate Stoker
11	Coal-Oil Slurry
12	Coal-Water Slurry
13	Bubbling Bed
14	Circulating Bed
32	Gas / Oil Fired Boiler
33	Pulverized Coal Boiler

Enter the id number for the boiler technology to use: 0
Please enter a value only from those listed above

Figure 11. Boiler technology selection display.

The number of boilers to be used in the analysis is next determined, as shown in Figure 12. CHPECON has been programmed to accept from 3 to 5 boilers. After you enter the number, CHPECON calculates the sizes of the boilers based on the number entered and the plant minimum continuous rating (PMCR). If a particular number of boilers results in sizes outside the limits of the selected technology, the program displays a warning and lets you enter another value. Although the program can continue with boiler sizes that are inappropriate for the technology, the results may not be completely valid due to the lack of data on that type of commercially produced boiler in the stated size range.

```
The number of boilers to use for the plant must be chosen before the boiler sizes can be calculated.

Either 3, 4, or 5 boilers can be chosen.

Your choices may be limited by the fraction of the PMCR that is devoted to process load.

          Enter the number of boilers to use: 4
          Is this correct? (Y/N) Y
          Calculated boiler sizes:

Boiler #1: 53000    Boiler #2: 90000    Boiler #3: 90000

Boiler #4: 90000

          Press any key to continue...
```

Figure 12. Boiler number and sizing display.

Selecting a coalfield is the next step in the procedure. Before this, the program displays another chance to quit. The coalfield candidates are selected based on their proximity to the base and the types of coal properties that are acceptable to the boiler technology. (The acceptable coal properties are modified under the "Update Databases" section of CHPECON.) Enter the maximum acceptable distance, in miles, on the screen shown in Figure 13. After you input the distance, the program searches through the coalfield database, and lists the total candidates and a breakdown of the coal types. When it completes the search, CHPECON asks whether it should search with a different distance. If you answer "yes" ("Y"), the program asks for the new distance and runs another search. If you answer "N" and no coalfields were found, the program abandons the case and returns to the menu. You must confirm that abandoning the work is really what is desired before the program will quit the case. If you answer "N" and at least one coalfield was found, the program moves to select the coalfield from the candidates.

```
Coalfields are identified as possible candidates based on proximity to the selected base, and on
properties that are compatible with the selected boiler technology.

        Distance from base to include:  500 miles

        Fields searched:  2428          selected:  10

          anthracite:  0                  lignite:  0

          bituminous:  10                 sub-bituminous:  0

 Search with a different distance? (Y/N)    Y
```

Figure 13. Coalfield search screen.

The coalfield is selected from the acceptable candidates listed on a screen similar to that shown in Figure 14. The selection light bar is activated when you tell CHPECON to choose a coalfield. Selection is performed by moving the light bar to the desired coalfield with the cursor directional arrows. If the number of candidates is larger than can be displayed on one screen, the screens are viewed by moving to the "Next" and "Previous" screens. To restrict the choices, minimum and maximum limits on sulfur and ash can be set and reset. Only coalfield candidates with sulfur and ash levels between the limits are displayed. After the coalfield is selected, the program computes the boiler performance and emissions at PMCR using the selected coal's properties.

The boiler inlet conditions are required to determine the amount of heat needed to convert water to high temperature water or steam. The input data is entered on the screen shown in Figure 15, and consists of make-up water and condensate return temperatures, and condensate return, blowdown, and boiler leakage fractions.

Initially, the system displays default values for each parameter. You can enter new values to overwrite the default values.

In addition to the amount of heat required per pound of water leaving the boiler, CHPECON requires the fraction of condensate returned to the boiler, and the blowdown and additional leakage in the boiler house (as fractions of water flow through the boiler) to calculate the required make-up water flow rate and sewer capacity at PMCR. The values displayed are adjusted to include estimates of other water use not directly part of the boiler.

ST	Location	R	Slfr	HHV	Dist	Moist	Ash	Voltls	Fxd C
IN	STRIP	B	0.90	13630	196	15.40	6.40	36.10	57.50
IN	STRIP	B	1.60	12760	218	12.70	10.40	35.90	53.70
IN	STRIP	B	1.50	13150	267	9.00	6.70	39.60	53.70
IN	MS NO.2 PIT	B	2.80	12830	286	8.60	10.30	37.60	52.10
IN	STRIP	B	5.90	12750	296	9.50	9.60	40.10	50.30
IN	STRIP	B	6.00	12630	296	8.10	9.90	39.30	50.80
KY	SURFACE MINE	B	1.00	13250	374	7.80	6.40	40.90	52.70
KY		B	1.20	13480	389	6.40	5.70	41.80	52.50
KY	UNDER-GROUND MINE	B	0.50	12870	406	6.00	9.70	38.10	52.20
PA	STRIP MINE, PONTARE	B	1.80	11970	438	11.80	9.40	36.10	54.50

Select this coalfield? (Y/N) Y

Figure 14. Display of coalfield selection from candidates.

```
Central Heating Plant Economics Evaluation Program     12/10/92
New plant (NP)

What is the leakage percentage?  3
The value should be between 0 and 5%

What is the condensate return percentage?  50
The value should be between 0 and 100%

What is the blowdown percentage?  5
The value should be between 0 and 10%

Water requirements @ PMCR: 267 gpm
Sewer (blowdown) requirements @ PMCR: 23 gpm

Press any key to continue...
```

Figure 15. Boiler water usage display.

The next step in the screening model is the calculation of plant and fuel storage area requirements. Another screen telling you of the next section and giving you the chance to return to the menu is displayed before proceeding. The first screen of this section reports on the required area for the plant and the building, and the heights of the plant and the stack, as shown in Figure 16. Next, the system displays an input screen (Figure 17) for information about the coal storage requirements. The system prompts you for the storage duration in both the long and short-term storage piles, the type of pile arrangement, and whether a rail car thawing shed is needed.

```
Central Heating Plant Economics Evaluation Program  12/10/92
New plant (NP)

Basic dimensions of plant:

        Plant area: 2 acres
        Building area: 14295 sq ft
        Plant height: 74 ft
        Stack height: 186 ft

Press any key to continue...
```

Figure 16. Basic plant dimensions.

Central Heating Plant Economics Evaluation Program 12/10/92
New plant (NP)

How many days of long-term coal storage are required? 90

The value should be between 60 to 100 days (default 90 days).

How many days of short-term coal storage are desired? 3

The value should be between 1 to 3 days (default 3 days).

What coal pile arrangement will be used for storing coal? 2

1 - Single pile 2 - Multiple piles
(default multiple)

Is a rail car thawing shed needed? (Y/N) N

Long term storage area: 3.35 acres
Short term storage area: 0.23 acres
Pond area: 0.40 acres

Track length required: 730 ft

Press any key to continue...

Figure 17. Coal storage input display.

Based on your input, CHPECON calculates the areas for the coal piles, and the track length for unloading coal rail cars. An alternate screen is displayed when a slurry fuel is used. The system determines the number of 500,000 gallon storage tanks needed. The system replaces the question regarding a rail car thawing shed with one concerning a rail car heating shed, and calculates the area occupied by the tanks and the rail length for unloading the fuel.

The next program section deals with screening issues that are less quantitative than the previous sections. The system again displays a notice about the next section, and offers an opportunity to exit. The questions in this section usually require you to select an answer from a number of displayed options. The most common formats are A/B/C/D and Y/N/M, representing a set of four options and Yes/No/Maybe, respectively. CHPECON evaluates the answers to the questions and determines an overall acceptability rating factor. This factor allows you to rank alternate operating strategies, technologies, and sites.

The first screen (Figure 18) asks if rail and/or highway transportation for the fuel is available. The next screen (Figure 19) asks about ash disposal sites and local sewage

availability. The third screen (Figure 20) asks for your assessment of community reaction to a plant's presence and the transportation of materials to and from it. The next screen (Figure 21) asks questions about the availability of enough water to meet the boiler's requirements, and the need for a new electrical substation. The question regarding lime availability (as shown in Figure 22) appears when the technology selected is a stoker boiler. The question changes to one about limestone availability when fluidized bed combustion boilers are selected. If the boiler uses coal-oil slurry or coal-water slurry as a fuel, this screen does not appear.

```
              Central Heating Plant Economics Evaluation Program     12/10/92
                                 New plant (NP)

Is rail transportation available for coal/limestone?
        Yes / No / Maybe (Yes but difficult)    «Y»

Is highway transportation available for coal/limestone?
        Yes / No / Maybe (Yes but difficult)    «Y»

        No problems with transportation.

Press any key to continue...
```

Figure 18. Transportation availability screen.

```
              Central Heating Plant Economics Evaluation Program     12/10/92
                                 New plant (NP)
Are there available sites for ash disposal? (A/B/C/D)   «D»

Ash disposal requirements are estimated to be 19 tons/day at  PMCR.
        A. No landfill is on or near base
        B. Landfill is near base.
        C. Landfill is on base not adjacent to plant site.
        D. Landfill is on base and adjacent to plant site.

        Ash disposal will not pose problems.
Is local sewage disposal available for boiler water discharge?
Effluent discharge at PMCR has been estimated to be 50 gpm.
Yes / No / Maybe (Yes but difficult)    «Y»

Press any key to continue...
```

Figure 19. Ash disposal and sewer availability screen.

Central Heating Plant Economics Evaluation Program 12/10/92 New plant (NP)
Is transportation of coal and/or ash through the community and/or base feasible? Yes / No / Maybe (Yes but difficult) «Y» Would the local community impose resistance to building a new boiler plant? Yes / No / Maybe (Yes but difficult) «N» Press any key to continue...

Figure 20. Community reaction screen.

Central Heating Plant Economics Evaluation Program 12/10/92 New plant (NP)
Water requirements have been estimated at PMCR to be 250 gpm. Is sufficient city water available for central steam plant makeup? Yes / No / Maybe (Yes but difficult) «Y» Will a new electrical substation be required for the new central heat plant load? Yes / No / Maybe (Yes but difficult) «N» Press any key to continue...

Figure 21. Makeup water and electrical substation requirements screen.

Central Heating Plant Economics Evaluation Program 12/10/92 New plant (NP)
Lime requirements at PMCR have been estimated to be 1375 lbs/hr. Is lime available for stoker boiler stack gas sulfur removal? Yes / No / Maybe (yes, but with difficulty) «Y» Press any key to continue...

Figure 22. Lime availability screen.

The next screen (Figure 23) asks about the status of the steam distribution system; both its routing/length and condition are evaluated. Additional screens are shown for the other case types (cogeneration, third party cogeneration, consolidation, and retrofit) and are similar in presentation and content to the ones shown for the new plant case.

Central Heating Plant Economics Evaluation Program 12/10/92 New plant (NP)
How accessible is the existing steam distribution system? (A/B/C) «C» A. Routing is very long and/or difficult. B. Routing is fairly accessible and medium length. C. Routing is short and accessible. What is the present condition of the existing steam distribution system? (A/B/C) «C» A. Poor condition B. Fair C. Good Press any key to continue...

Figure 23. Steam distribution status screen.

The original screening model has been expanded to include more questions covering a wider scope of plant activities. More importantly, a scoring procedure has been developed which will allow you to easily interpret the rankings of different facilities. The program will now produce an overall score and a category score in addition to the previous messages in response to screening questions. These scores can be used to rank facilities, and are very useful when comparing the attractiveness or feasibility of different CHP sites and technologies.

Scoring Procedure

The screening model is divided into various categories: development and construction, fuel supply and site access, ecology, social considerations, facility services, waste handling and emissions, military, consolidation, cogeneration, and third-party cogeneration. Some of these categories, such as consolidation and cogeneration, will not apply to all facilities. The program presents a series of questions in each category, with each question having several possible responses. Most of the responses require you to choose between "Yes," "No," or "Maybe." For some questions, specialized responses are offered. Each question carries a weighting factor from 1 (lowest weight) to 10 (highest weight), depending on the relative impact of that topic on the central heating plant. Each possible response carries a point total from 0 (lowest) to 5 (highest). Points are allocated to responses by considering the contribution, or detriment, each positive or negative response will have upon the central heating plant.

The total score for a given question is derived by multiplying the question weight by the response score. For example, a question that carries a weight of 8, and a response that provides 3 points, will produce a score of 24 for that question. The score for each

category is the sum of the point totals for all questions in the category. A percentage score is developed by dividing the actual score by the total possible score for each section. The percentage score makes it easier to compare the results for different facilities. An overall score is developed by averaging the percentage scores for all categories. The CHPECON program will keep track of screening model scores in order to advise you on the relative attractiveness of the CHP in each category, as well as the overall feasibility of the facility considering all categories.

The following sections list the questions and the numerical weights, which are listed in bold text immediately after each question. A short description of each category and its importance to central heating plants is also provided.

Development and Construction. This section of the screening model covers a wide variety of topics regarding construction feasibility and possible problems that may be encountered in the development of the central heating plant. For example, this section will ask about removing construction waste, soil suitability, zoning regulations, existing base equipment, space constraints, and general site conditions.

Q. Are contractors available for the construction of the CHP from localities near the base? **10**

Q. Are any existing pipelines that will be removed or accessed in the construction of the proposed CHP insulated with asbestos in any form? **9**

Q. Is the site capable of supporting the building and equipment foundation for the CHP? **8**

Q. Has the area planned for the CHP been used for other purposes which would require soil remediation, waste cleanup, or other preparation before being suitable for construction? **8**

Q. Is the site accessible for construction personnel and equipment, for example, by being in close proximity to primary and secondary roads and being free of underpasses that may limit access? **7**

Q. Does the soil at the site meet the requirements for minimizing the seepage of wastewater? (If not, more expensive control measures must be put into place, such as pond linings) **6**

Q. Is there sufficient level ground (considering a minimum of land clearing and backfilling) to place the CHP facility? **6**

Q. Is there adequate room around the base for utility access connections to CHP (e.g., buildings are adequately separated and sidewalks/pavement do not limit access to connections)? **6**

Q. Are there any terrain issues such as underground streams or rock formations that would prohibit or interfere with the construction of the CHP? **6**

Q. Is there sufficient area for storage of construction wastes at the CHP facility? **5**

Q. Is the area currently free of infrastructure constraints (e.g., major highways, houses, railroads, transmission lines, oil and gas pipelines, cemeteries)? **5**

Q. Is the base initiating or currently undergoing other construction that would interfere with (or prohibit) the construction of the CHP? **5**

Q. Are staff available at the base to coordinate construction activities with the contractor(s)? **5**

Q. Does the area planned for the CHP have a problem in flooding or may have one once construction is completed? **5**

Q. Are adequate sites available for accepting material removed while clearing for the CHP's construction? **4**

Q. Is the site in a seismologically stable region? (If not, additional costs may be incurred to insure the facility's stability) **4**

Q. Are any of the areas that will be disturbed during the construction of the proposed CHP insulated or in some other way involved with asbestos (e.g., vinyl asbestos floor tile)? **4**

Q. Has the area been evaluated to determine whether conditions do not materially differ from those ordinarily encountered on a project such as that contemplated? **4**

Q. Are adequate sources available nearby for material needing to be supplied (e.g., for dikes or dams) for the CHP's construction? **3**

Q. Are there any zoning regulations that would need to be addressed before the construction of a CHP could begin? **3**

Q. Are staff available to inspect / supervise the construction and verify its progress? **3**

Q. Is there any planned schedule for removal of existing equipment relying on the construction of the CHP that would need to be adjusted if the CHP encountered a delay in startup? **3**

Fuel Supply and Site Access. This section of the screening model is devoted to questions of providing fuel, equipment, and personnel to the facility on a daily basis. For example, questions are included on topics such as rail and highway delivery of coal, and fuel supply contracts.

Q. Is rail transportation available for coal/limestone? **10** (if coal)

Q. Is highway transportation available for coal/limestone? **10** (if coal)

Q. Will the base be able to establish coal supply contracts of the following types: **10** (if coal)

a. transportation contracts direct from mine to base
b. transportation contracts from mine to base through intermediate sites

Q. Will the base be able to establish fuel oil supply contracts of the following types: **10** (if oil)

a. long-term oil transport contract with existing oil pipeline owner
b. long-term oil trucking contract from tank farm to project
c. fuel oil purchase contract(s)

Q. Will the facility be able to establish gas purchase contracts of the following types: **10** (if gas)

a. firm or interruptible contract
b. domestic or Canadian producer or marketer
c. pipeline or local distribution company
d. fixed price
e. fixed price period, thereafter price tied to specified index or indices
f. percentage or formula price tied to fuel component of energy sales rate under power purchase contract
g. pre-paid gas contract

Q. Is the track condition of existing railroad rights-of-way capable of supporting coal deliveries and reactants for the station? **5** (if coal)

Q. Is there enough room at the site for the necessary rail extensions for parking the coal train while it is being unloaded? **5** (if coal)

Q. Are any special setups needed for access routes, such as bridges or other special right-of-way developments that would limit access to the site on a daily basis? **4**

Q. Are the railroad rights-of-way accessible from the proposed CHP site over relatively flat terrain? **3** (if coal)

Ecology. This section addresses the very important topic of environmental factors. These questions have an impact on the feasibility of the site in light of ecology considerations and preservation of plant and animal wildlife. Many Federal regulations have been promulgated in the past decade to prevent ecological deterioration, and military facilities are expected to comply with these regulations.

Q. Are there any threatened or endangered species of flora or fauna located on or near the base that may be affected by the construction and/or use of a CHP for the base? **10**

Q. Is there a potential for local resident opposition to the pollutant emissions and waste production from a CHP? **10**

Q. Is the general area located near either natural formations and plants or man-made structures where the perceived presence of a plant contributing to acid rain would cause unforeseen problems? **9**

Q. Is the site potentially impacted by concerns over issues such as soil / shore erosion? **7**

Q. Is the area planned for the CHP part of a protected wetlands, requiring special handling or creation of comparable wetlands areas when using this one? **7**

Social Considerations. This section of the screening model develops the attractiveness of the central heating plant in light of local community concerns. Military facilities have the potential to adversely affect the local community through such factors as noise, traffic, air and water pollution, and aesthetic considerations.

Q. Is transportation of coal and/or ash through the community feasible? **10** (if coal)

Q. Would the local community impose resistance to building a new boiler plant? **10**

Q. Are there locations of archaeological and historic properties nearby that would significantly affect the suitability of the base for a CHP? **10**

Q. Are there nearby national or state parks or recreation areas, Indian reservations, productive farmland, or major airports that would affect the suitability of the base for a CHP? **9**

Q. Is industrial contamination of the water supply a major issue in the community? **9**

Q. Are there any regulations concerning ambient noise that may impact the placement and operation of the central heating plant at the site? **6**

Q. Are there presently or will there be future neighbors adjacent to the base that would limit the placement of the CHP at the base? **6**

Q. Is there enough room at the base to distance the CHP from the base's boundary to insure compliance with noise regulations? **6**

Q. Is the area planned for the CHP considered or potentially considered a cultural resource that needs to be maintained / preserved? **6**

Q. Have construction projects similar to the proposed CHP generally been successful (or at least met with little or no community opposition)? **5**

Q. Is the community's economic situation conducive to the start of a large construction project such as the CHP? Having a project requiring community participation in jobs when the area is experiencing local deficits, is more likely to be accepted. **4**

Facility Services. This section of the screening model addresses basic utility services such as electrical and water supply, sewer, and steam distribution system access. The placement of a new central heating plant at an existing base may cause problems or incompatibilities with original equipment or facilities.

Q. What is the present condition of the existing steam distribution system? **10**

Q. How accessible is the existing steam distribution system? **10**

Q. Is a nearby limestone supply available? (for FBC coal boilers only) **10**

Q. Is lime available for stoker boiler stack gas sulfur removal? (for stoker coal boilers only) **10**

Q. Is a continuous supply of makeup water available? (If not, it would need to be brought in as available and stored on base for the continual needs of the facility) **9**

Q. Is there direct or nearly direct access to transmission lines for delivery of electricity to the CHP? **7**

Q. Are there any staff already capable of performing the instrumentation calibration and maintenance required of the proposed CHP? **6**

Q. Will a new electrical substation be required for the new central heat plant load? **5**

Q. Will the existing facility's distribution system be able to utilize the new CHP steam output without modification? **5**

Q. Is adequate traffic control supplied by the existing facilities? **2**

Q. Are the current staff utilizing written operating procedures and operating the existing facility in such a fashion that the addition of the proposed CHP will be incorporated smoothly? **2**

Waste Handling and Emissions. The topic of waste handling and emissions is important to the feasibility and attractiveness of a central heating plant site. Considerations such as ash disposal, waste removal, wastewater discharge, and air emissions must be carefully addressed by planners of the CHP.

Q. Are there available sites for ash disposal? **10**

Q. Is there one or more outside agencies with sites that are or can be used for landfill of the collected ash? **10**

Q. Is local sewage disposal available for boiler water discharge? **10**

Q. Will ash and other discharges from the CHP be classified as hazardous wastes? **9**

Q. Can blowdown water and other wastewater be delivered directly to a sewer system? If not, treatment and delivery to nearby streams or the ground will require additional cost. **7**

Q. The National Ambient Air Quality Standards and the Prevention of Significant Deterioration Program restrict the total amount of an air pollutant that may be added to an area. Is there other pollutant-emitting equipment in the area which would limit the potential of a new central heating plant being constructed? **7**

Q. Does construction of the proposed CHP offer the possibility of generating tradeable air emissions credits for the base? **6**

Q. Are there local regulations regarding the handling and disposal of the wastes from an operating CHP? **2**

Military. This section of the screening model addresses questions specific to the military capacity in which these central heating plants will serve. For example, base security and availability are extremely important to support the mission of the military base. Given the importance of the central heating plant to many base services, this section should be considered carefully.

Q. Will the base have access to a secure fuel supply in the event of a military conflict? **10**

Q. Will normal operations of the CHP such as outside contractor ash removal or fuel deliveries affect base security? **9**

Q. Will construction of the CHP interfere with the security of the base? **8**

Q. What is the likelihood that a major change in the "mission" of the base will occur in the future that will impact the CHP (e.g. base closure, expansion, etc)? **8**

Q. Will current projects or activities at the base interfere with the construction of the CHP, necessitating rescheduling or cancellation of certain base functions? **5**

Consolidation. This section addresses the case in which multiple decentralized heating units are consolidated into one large central system. A central heating plant and steam distribution system will need to be installed in the event of a consolidation. The attractiveness of consolidation is determined by a number of factors presented in this section.

Q. Does the base have a relatively flat thermal load profile during the typical day? **10**

Q. Can you convince the base commander and existing building operators of the advantages of a centralized heat plant? **10**

Q. Is the distribution system going to be hot water or steam? **10**

Q. Do the existing building utilize steam or hot water for heating (as opposed to other space conditioning methods such as forced air space heaters)? **10**

Q. Does the base have a process steam load which requires steam greater than 200 psi and which will be included in this consolidation? **10**

Q. What is the load density of the base? [used in calculation]

Cogeneration. The option of cogenerating electricity at the base is analyzed in this section of the screening model. Cogeneration, or providing electricity for the base's own needs, may be attractive in certain situations. Important factors include local utility considerations and plant operating characteristics such as the daily or monthly load profile.

Q. How many hours per year will the plant be operated? **10**

Q. Can/does the existing electric distribution system use a single point supply and metering station near the proposed cogeneration site so that the cogenerated electricity can displace purchased power? **10**

Q. Is it likely that the base will encounter a reduction of thermal or electrical demand in the foreseeable future? **10**

Q. Will the utility company supply service to maintain and repair interconnection facilities? **10**

Q. Will the local electric utility be cooperative in setting the electrical interconnection and stand-by power costs? **10**

Q. Does the local electric utility use coal as their primary fuel? **10**

Q. What is the base's average ratio of hourly electric power to hourly steam for a typical day? **10**

Q. Bringing the temperature of water to an acceptable level before discharging may require cooling impoundment, a cooling tower, or once-through cooling. Is there an adequate sink for dissipating thermal discharges from the facility? **7**

Q. What is your present electric rate? [used in calculation]

Q. What is the anticipated cost of fuel? [used in calculation]

Q. What is the facility's electric load? [used in calculation]

Q. What is the facility's load factor? [used in calculation]

Q. What is the base's annual electric power to annual steam demand ratio? [used in calculation]

Third-Party Cogeneration. This section of the screening model addresses a subset of cogeneration in which the base not only cogenerates electricity but also sells a portion of that electricity back to the local utility. The feasibility of third-party cogeneration is determined by a number of the factors presented in this section.

Q. What is the cost ($/MMBtu) of thermal energy provided by the base? **10**

Q. What is the expected cost ($/MMBtu) of thermal energy provided to the base by the third-party cogenerator? **10**

Q. How many hours per year is the third-party cogeneration facility expected to be operated? **10**

Q. What are the daily characteristics of thermal energy demand by the base: Will significant electric generation capacity be consistently available between 8:00 AM and 6:00 PM? **10**

Q. What are the monthly characteristics of thermal energy demand by the base: Will significant electric generation capacity be consistently available from July 1st to September 15th? **10**

Q. What is the expected cost of electricity (cents/kWh) that will be produced by the third-party cogeneration facility, given today's fuel prices? **10**

Q. What electric buy-back rates (cents/kWh) are currently available from the local utility? **10**

Q. What is the current rate (cents/kWh) of electricity experienced by the base? **10**

Q. If the cogeneration facility will supply the base with electricity as well as thermal energy, what is the most likely rate that the cogenerator will offer to the base? **10**

Q. Is the local utility capacity-constrained? (Does there appear to be a shortfall of electric generation supply in the foreseeable future?) **10**

Q. Is wheeling of cogenerated electricity to other demand centers a realistic alternative to local buy-backs? **10**

Q. Does the existing heat plant require retrofit, repair, or expansion? **10**

Q. Will the thermal output of the facility be at least 5% of the of the total energy output? **10**

Q. Will electric power output plus one-half the useful thermal energy output be at least 42.5% of the fuel heat input if the useful thermal energy is at least 15% of the total, and at least 45% otherwise? **10**

Q. Is access to transmission facilities provided only by the operating policy and/or regulatory control of the local utility? **10**

Q. Are other Independent Power Production generators established in the general area of the base that would serve as competition? **9**

Q. Is electricity demand consistent over 24 hours? If consumption is primarily within the day shift, matching electrical and thermal demands will be difficult. **9**

Q. Are power pools (for dispatching of the pooled generation facilities) in place or proposed within the area of the base? **8**

Q. Are long term contracts for access to transmission facilities available? **5**

Q. Are short term contracts for access and wheeling power available? **5**

Q. Are regional transmission system planning organizations currently in operation or proposed within the area of the base? **5**

Q. Can the base's generating operations be coordinated / integrated with the utility to allow for dispatchability by the utility? **5**

Q. Are brokers for the buying and selling of transmission services / power operating within the area of the base? **4**

After evaluating the plant, CHPECON reviews the applicable emission regulations to determine if the plant meets the requirements. The program displays whether or not the plant meets the requirements; a list of the passed and failed requirements are contained in a report that can be printed later.

A final screen is displayed telling you that the screening model has been completed and that CHPECON is returning to the menu.

Screening Model Option 2: Use Existing Case

This option allows you to retrieve an existing screening case file to be used as the base for a new screening case. Entering only the changed information will produce the new result. A review of the different pieces of information allowed a determination of the parameters that fed from one section to the next, to establish the inter-dependencies. Knowing this, the requirements for answering questions in each topical area were established. For example, a change in the emission regulation region of the base would not affect anything else (but it would require another review of the ability of the proposed facility to meet the regulations). However, a change in boiler technology or the number of boilers could require a different coal. It also required the addition of a number of modules to handle the requirements checking, display, and use interrogation for the general facility questions. Additional modifications were needed throughout much of the screening model modules to recalculate intermediate values.

User Interface

Access this option through the main menu shown in Figure 3 by selecting the **Screening Models** option to bring up the menu shown in Figure 4. Selecting any of the types of systems to be studied brings up the menu shown in Figure 5. Selecting the **Use existing case** option brings up the additions implemented in this task.

CHPECON then displays a list of existing cases of the type you selected from the menu in Figure 4. (This is the same selection list as used in the other sections of CHPECON.) After identifying the existing case, enter a new filename for the results of this operation. This option does not modify the existing case; it leaves it intact so any other analyses done with that screening case can still be identified by the filename. The contents are copied to the new file specified. The contents are also read into the program for use and modification by this routine.

Once the program reads the entries, it displays the menu in Figure 24. From this, you can access and modify each of the major topic areas involved with the screening analysis. Any topics that need to be addressed are highlighted by the note "needed" (as shown in item 7 of Figure 24).

```
Central Heating Plant Economics Evaluation Program   08/01/92
New plant (NP)

1 - Update military base emission regulation region
2 - Update steam flow entries for PMCR calculations
3 - Update leakage, blowdown, condensate fractions & temps
4 - Update boiler technology and number of boilers
5 - Update coalfield selection / boiler operation
6 - Update plant sizing calculations
7 - Update general questions - needed

Q - Exit update screening section
```

Figure 24. Topic selection menu.

When you select the **Update general questions** option, the system displays the screen shown in Figure 25. The information on the screen depends on the type of facility being studied. Every facility type except the new plant used as an example has multiple screens for display; options for moving between screen pages are also displayed.

Central Heating Plant Economics Evaluation Program 08/01/92 New plant (NP)
Is rail transportation available for coal/limestone? Y
Is highway transportation available for coal/limestone? Y
Available sites for ash disposal: D - Landfill on base; adjacent to site
Is local sewage disposal available for boiler water discharge? Y
Transportation of coal/ash through the community/base feasible? Y
Local community resistant to building a new boiler plant? N
Sufficient city water available for central steam plant makeup? Y
New electrical substation required for the plant load? N
Nearby limestone supply available for FBC boiler?
Lime available for stoker boiler stack gas sulfur removal? Y
Existing steam distrib system? C - Routing short and accessible
Condition of existing steam distribution system? C - Good
« Exit question update section »

Figure 25. New plant general question review.

The questions are shown with the current answers, either those for the existing case initially used or as you updated them in exercising this option.

Select a particular option by using the <Up> and <Down> cursor keys to highlight the question, then pressing the <Enter> key. Once that is done, a window appears overlaid on the questions as in Figure 26. After you answer the question, the program returns to the list of general questions and asks you to select another question, move to another screen (if available), or return to the topic selection menu (Figure 24).

Central Heating Plant Economics Evaluation Program 08/01/92 New plant (NP)
Is rail transportation available for coal/limestone? Y
Lime requirements at PMCR have been estimated to be 1333 lbs/hr.
Is lime available for stoker boiler stack gas sulfur removal?
Yes / No / Maybe (yes, but with difficulty) (Y/N/M) «Y»
« Exit question update section »

Figure 26. General question update.

Screening Model Option 3: Delete Existing Case from Storage

Selecting this option brings up the case file list as shown in Figure 6 with a prompt asking for the name of the file to be deleted. The list contains only the files that are the same case type as indicated on the main menu header under the current date.

Once you enter the file name, the program checks to see that it is an existing case file. If not, the program returns to prompt you for another file. If you entered an existing file name, the program asks you to confirm that the file is to be deleted by answering "Y" to the prompt. If confirmed, the program deletes the file and removes the entry in the case list database file.

The program continues to prompt for case files to be deleted until you make no entry (blanks or spaces) for the file name. The program then returns to the screening model main menu.

Screening Model Option 4: Print Case Study

Selecting this option causes the program to display the file list, as shown in Figure 6. The prompt changes to ask for the name of the file holding the case to be printed. The list of files contains only those that are the same case type as indicated by the main menu header under the current date.

If the file name you enter does not match an existing file, the program returns to the name prompt. If you enter blanks, the program returns to the main menu. Once an acceptable file name is entered, the program asks for confirmation that it should start printing. If you do not confirm the program returns to the main menu. If you confirm, the program begins printing. A sample screening model output is presented in Appendix A.

The printout can be stopped early by pressing the <ESC> key. This stops printing and returns you to the main menu. Otherwise, the program completes the task of printing, and then returns to the main menu. Note that if the printer side of the equipment is equipped with any sort of buffer, the program may indicate that it has finished by returning to the main menu even though printing is not actually complete.

4 Cost Model Operation

The cost model is used to analyze the capital and operating/maintenance costs of the boiler plant under consideration. In the case of retrofitting an existing heavy-oil plant, the analysis compares the cost of continuing with the existing fuel use to the approximate investment cost of retrofitting to coal use.

When you select this option from the main menu of CHPECON, the system displays the menu shown in Figure 27. Enter the number or letter indicated to select one of the options. Enter 1 through 5 to analyze the cost for one of the five types of cases. Enter P to print a report. Enter Q to leave this option and return to the CHPECON main menu.

```
Central Heating Plant Economics Evaluation Program
11/19/92
Main menu — cost model

1 -- New plant

2 -- New plant with cogeneration

3 -- New plant with third-party cogeneration

4 -- New plant with consolidation

5 -- Retrofit plant

P -- Print report

Q -- Quit (return to main menu)

Use ↑ ↓ to move highlight or enter first character to select option

New boiler plant cost analysis for heating and process loads
```

Figure 27. Main menu display of the cost model.

Selecting an option causes CHPECON to display a screen similar to Figure 28. The file name is shown in the left column titled “File.” The next column, titled “CT” is the type of case being displayed, based on the option you selected, as shown in Table 1.

--File--	CT	--Case description--------
RT-1	RT	Fort Sheridan / Haley AAF

Enter file name to cost:
? to list more files, blanks to quit

Figure 28. Screen display for case (file) selection in retrofit plant - cost model.

Table 1. Case type identification for screen display.

CT	Case Type
NP	New plant
CG	New plant with cogeneration
TP	New plant with third-party cogeneration
CN	New plant with consolidation
RT	Retrofit plant

The case description, shown on the right of the screen, is the name of the base entered in the update military base information routines. To select a particular case for cost modeling, enter the file name listed on the left. Because the cost model requires the input of information from the screening model, only the cases listed as available can be studied. If a file name is entered that does not exist, the program will prompt you for another name. If more files are available, entering a "?" will show successive screens of available files. Entering blanks (spaces) for the filename will return you to the cost model menu.

Once an available file is displayed, the program begins asking for information to be used in this assessment. The series of screens will be the same for each case type except where noted in their descriptions. The initial input screen (Figure 29), first asks for the expected life of the plant in years. The discount rate is the value used to calculate the present value of the expenses during construction and operation. The next two questions are asked only when the case is not a retrofit. The current net salvage value applies to the plant in the condition it is expected to be in when it is actually taken out of service. If taking the plant out of service, dismantling, and removing it will cost more than the gross salvage value, enter the net cost as a negative net salvage value. The net salvage value for the new plant under consideration is entered as a percentage of its total cost. It is handled in this manner because the cost of the new plant hasn't been determined.

Central Heat Plant Economic Evaluation Program 12/01/92 Retrofit Plant (RT)
How many years will the plant be operated? 25 (maximum allowable value is 25) What is the current discount rate? 10 % What is the current net salvage value of the existing system? $ 0 PLEASE NOTE: If disposal cost is greater than salvage value, enter the value as a negative number What % of Adjusted Investment Cost is the net salvage value of the new or retrofit system? (acceptable values are between -15% and +15%) PLEASE NOTE: If disposal cost is greater than salvage value, enter the value as a negative number. Would you like to change any of the values on this screen? N

Figure 29. Economic data input screen 1.

The next input screen (Figure 30), asks for the year of study and the year that the facility will start operation. The year of study is defined as the year for which you have information on the cost indices or escalation factors that will be entered on the following screens. The year the facility will start operation is provided so that the starting year can be set to the same value for various cases if desired, since different cases have different construction times.

Central Heat Plant Economic Evaluation Program 12/01/92 Economic Analysis Input Retrofit Plant (RT)
What is the year of study? 1988 Warning: the year of study must correspond to the year of index escalation values. When will the facility start operation? 1991 The earliest that you can start the operation of the facility is 1991 due to the 2 year construction period. Would you like to change any of the values on this screen? N

Figure 30. Economic data input screen 2.

The next two screens modify their displays based on the type of data being entered. To account for the cost of each type of activity and material that needs to be considered in the analysis, cost indices or escalation factors are requested. If you know the cost indices, enter them after telling the program to use the indices. CHPECON will then calculate the escalation factor to be used. Alternatively, if the escalation factors have

been calculated, you can enter them directly. Escalation factors and cost indices can be mixed; however, the year used must be the same for all values.

The first of these two screens asks for values to adjust the capital costs for all equipment and nonlabor operating and maintenance such as chemicals. Figure 31 shows the screen display that appears when cost indices are used for both terms, and Figure 32 shows the display used for calculated escalation factors.

Central Heat Plant Economic Evaluation Program
12/01/92
Economic Analysis Input
Retrofit Plant (RT)

The Capital Equipment Escalation Factor can be calculated using ONE of two sources of information:

1. Engineering News Record Magazine, 'Construction Cost Index.'

2. Army Regulation Number 415-17

Which one will be used for the analysis? 1
Current Cost Construction Index for 1988: 4566.87
Capital Equipment Escalation Factor for 1988-1988: 1.000

The Total Non-Labor Operating and Maintenance Escalation Factor can be calculated using ONE of two sources of information:

1. Chemical Engineering Magazine., M & S Steam Power Index

2. Army Regulation Number 415-17

Which one will be used for the analysis? 1
Current value of Steam Power Component of Marshall & Swift Equipment Cost Index for 1988: 856.60

Total Non-Labor O & M Escalation Factor for 1988-1988: 1.000

Would you like to change any of the values on this screen? N

Figure 31. Economic data input screen 3, using cost indicies.

Central Heat Plant Economic Evaluation Program 12/01/92 Economic Analysis Input Retrofit Plant (RT)
The Capital Equipment Escalation Factor can be calculated using ONE of two sources of information: 1. Engineering News Record Magazine, 'Construction Cost Index.' 2. Army Regulation Number 415-17 Which one will be used for the analysis? 2 Capital Equipment Escalation Factor for 1988-1988: 1.000 The Total Non-Labor Operating and Maintenance Escalation Factor can be calculated using ONE of two sources of information: 1. Chemical Engineering Magazine., M & S Steam Power Index 2. Army Regulation Number 415-17 Which one will be used for the analysis? 2 Total Non-Labor O & M Escalation Factor for 1988-1988: 1.000 Would you like to change any of the values on this screen? N

Figure 32. Economic data input screen 3, using escalation factors.

The second of these two screens asks for values to adjust the operating and maintenance and construction labor costs. Figure 33 shows what is displayed when indices are used, and Figure 34 shows the display for calculated escalation factors.

Central Heat Plant Economic Evaluation Program
12/01/92
Economic Analysis Input
Retrofit Plant (RT)

The Operating And Maintenance Labor Escalation Factor can be calculated using one of the following sources of information:

1. Engineering News Record Magazine, Skilled Labor Index

2. Army Regulation Number 415-17

Which one will be used for the analysis? 1
Skilled labor index for 1988: 4133.54
Operating and maintenance labor escalation factor for 1988-1988: 1.000

The Construction Labor Escalation Factor can be calculated using one of the following sources of information:

1. Chemical Engineering Magazine, Construction Labor Index

2. Army Regulation Number 415-17

Which one will be used for the analysis? 1
Construction labor index for 1988: 264.80
Construction Labor Escalation Factor for 1988-1988: 1.000

Would you like to change any of the values on this screen? N

Figure 33. Economic data input screen 4, using cost indicies.

Central Heat Plant Economic Evaluation Program
12/01/92
Economic Analysis Input
Retrofit Plant (RT)

The Operating And Maintenance Labor Escalation Factor can be calculated using one of the following sources of information:

1. Engineering News Record Magazine, Skilled Labor Index

2. Army Regulation Number 415-17

Which one will be used for the analysis? 2
Operating and maintenance labor escalation factor for 1988-1988: 1.000

The Construction Labor Escalation Factor can be calculated using one of the following sources of information:

1. Chemical Engineering Magazine, Construction Labor Index

2. Army Regulation Number 415-17

Which one will be used for the analysis? 2
Construction labor escalation factor for 1988-1988: 1.000

Would you like to change any of the values on this screen? N

Figure 34. Economic data input screen 4, using escalation factors.

Next, the system displays a screen concerning coal costs and investment costs as shown in Figure 35. The transport costs are based on the coal shipped the straight line distance between the coal field and the base as determined by the screening model (which may not be the actual path that would be taken by the coal to get to the base). The escalation rate should be changed from 0 percent only if it is know that the cost for transporting coal will be significantly different compared to the inflation rate. The 10 percent investment cost exclusion, which can be applied if you choose, is an adjustment to the total investment cost applicable to some Federal energy programs to influence the life cycle cost favorably and increase the likelihood of the project's acceptance.

Central Heat Plant Economic Evaluation Program 12/01/92 Economic Analysis Input Retrofit Plant (RT)
Coal transportation cost: 2.18 cents/ton-mile. Coal transportation cost escalation rate: 0.00 % (escalation above general inflation) Apply the 10% investment cost exclusion? (Y/N) N Would you like to change any of the values on this screen? N

Figure 35. Economic data input screen 5.

The next screen (Figure 36) asks for the base year costs for the four types of energy used or potentially used in a plant. You can accept the values displayed by entering "A" or change them by entering "C." This causes the program to go to each DOE full cost for any potential changes. If you made a mistake while changing values, enter "R" at the prompt to reset the costs to their original values. Once the displayed values are accepted, the program continues. The coal-oil and coal-water slurry boilers result in a slightly different display, which includes the calculated slurry-costs based on the component costs.

Central Heat Plant Economic Evaluation Program 12/01/92 Economic Analysis Input Retrofit Plant (RT)
Energy costs calculated based on 1981 DOE costs and escalation rates for the coalfield and base DOE regions. Base year for study: 1988 Coalfield DOE region: 5 Cost of DOE coal: 57.828 $/ton(11,250 Btu/lb coal) Equivalent cost : 67.595 $/ton(adjusted for 13,150 Btu/lb coal selected during screening) Base DOE region: 5 Cost of DOE distillate: 1.486 $/gallon Cost of DOE residual: 1.442 $/gallon Cost of DOE electricity: 0.050 $/kWh Accept values/Change values/Reset to original values (A/C/R) « »

Figure 36. Economic input screen 7 for cases using coal.

All New Plant Cost Model Report Displays

The program continues for all cases (except retrofit) in the same fashion. The program calculates the costs for each logical area of the coal-fired boiler plant such as boilers,

coal and ash handling equipment, tanks, and pumps. While calculating, CHPECON displays a summary page to which it adds a line at a time. Figure 37 shows an example of a completed summary page. When necessary, the screen switches to a display where one or more questions are asked; whether optional equipment is to be included, whether rail or truck transport is desired (when either is permitted), and what the sizes of some components are to be.

Cost Summary

Annual Labor Costs: $ 1,284,742
Total Boiler capital costs: $ 12,777,480
Total Coal Handling Capital Costs: $ 1,187,575
Total ash handling capital costs: $ 495,912
Mechanical Collector Capital Costs: $ 72,256
Total dry scrubber and lime system capital costs: $ 686,494
Total baghouse and I.D. fan capital costs: $ 1,954,594
Boiler Water Treatment System Capital Costs: $ 905,828
Tank Capital Costs: $ 551,500
Pump Capital Costs: $ 180,948
Capital air compressor costs: $ 67,945
Waste Water Treatment System Capital Costs: $ 83,121
Total Piping and Stack System Capital costs: $ 3,037,520
Total Instrumentation Capital Costs: $ 800,000
Total Electrical System Capital Costs: $ 1,024,437
Spare Parts, Tools & Mobile Equipment Capital costs: $ 1,219,813
Total building and service capital costs: $ 8,442,234
Annual O & M (materials/supplies) costs: $ 575,159
Direct costs: $ 15,337,203
Total Capital Plant Costs: $ 48,824,860

Press any key to continue...

Figure 37. Display of cost summary for all cases except retrofit.

After completing the calculations that define the plant investment, CHPECON runs through the expected life of the plant, calculating the operating costs that would be incurred. Figure 38 shows a summary of the costs, which can be listed on more than one screen. The first column lists the year. The second column shows the adjusted investment cost, either the total value or 90 percent of the total if the 10 percent cost exclusion was applied. The next three columns list the annual total energy and transportation costs, nonenergy operating and maintenance costs, and repair and replacement costs. The existing and new salvage value column can have only two values. The first is the salvage value of the existing plant, which is placed at the midpoint of construction. The second is the salvage value of the considered plant and is based on the investment costs and the percentage salvage value you enter. One additional column appears for cogeneration cases to keep track of the cost of electricity

that could be displaced by using electricity generated by the facility. It is taken as a credit against the other costs when calculating the present value life cycle cost and levelized cost of service. The next screen, shown in Figure 39, is a report of the annual coal usage, annual facility output, and some values that you defined. This information is used to calculate the costs and the present value of the expenses.

Central Heat Plant Economic Evaluation Program
12/01/92
Facility Financial Statement
New Plant (NP)

Yr.	Adjusted Investment Cost	Energy and Transport. Costs	Non-Energy and O&M Costs	Repair and Replacement Costs	Salvage (Existing and New)
1991	72,642,598	0			
1992	2,877,113	1,989,121	0		
1993	2,883,651	2,309,404	0		
1994	2,888,001	2,309,404	122,394		
1995	2,894,851	2,309,404	0		
1996	2,901,803	2,309,404	31,882		
1997	2,906,637	2,309,404	122,394		
1998	2,913,971	2,309,404	109,101		
1999	2,921,513	2,309,404	383,324		
2000	2,929,209	2,309,404	122,394		
2001	2,934,822	2,309,404	508,301		
2002	2,942,968	2,309,404	0		
2003	2,951,392	2,309,404	181,003		
2004	2,960,022	2,309,404	0		
2005	2,966,638	2,309,404	109,101		
2006	2,975,839	2,309,404	167,518		
2007	2,985,387	2,309,404	383,324		

Press any key to continue...

Figure 38. Yearly cash flow display for the all new plant cost model.

Central Heat Plant Economic Evaluation Program 12/01/92 Facility Financial Statement New Plant (NP)
Annual Coal Usage: 32,755 tons (dry) 35,703 tons (wet) Annual Facility Output: 728,400 MMBtu 728,400 thousand lb steam Discount Rate: 10 % Coal Transportation Cost: 2.18 cents/ton-mile Coal Transportation Cost Escalation: 0.00 % Year of Study: 1988 Starting Year of Operation: 1992 Ending Year of Operation: 2016 10% Investment Cost Exclusion IS NOT applied. Press any key to continue...

Figure 39. Displayed report of coal use, energy output, and selected inputs.

The next screen (Figure 40) is a report of the life cycle costs in terms of their present value in the year of study. There is one value for each column on the annual summary screens displayed previously. Based on these values, a net life cycle cost is calculated, in dollars of the year of study. The levelized cost is then calculated from this in terms of cost per million Btus of energy (or $1000 pounds of steam). This specific cost can be used to compare different boiler technologies and coal types.

Central Heat Plant Economic Evaluation Program 12/01/92 Facility Financial Statement New Plant (NP)
LIFE CYCLE COST PV 'Adjusted' Investment Costs = $ 54,577,459 + PV Energy + Transportation Costs = $ 19,977,608 + PV Annually Recurring O&M Costs = $ 15,530,719 + PV Non-Annually Recurring Repair & Replacement = $ 933,994 - PV Salvage Value of Existing System = $ 0 - PV Salvage Value of New/Retrofit Facility = $ 0 --- Total Life Cycle Cost (1988) = $ 91,019,78 Levelized Cost of Service (1992 start) = 20.155 $/MMBtu Print report? (Y/N) N

Figure 40. Life cycle cost summary (present value) for plant under study.

Retrofit Case Cost Model Report Displays

The results of the analysis for any retrofit case consists of one or more screens showing the investment costs for the retrofit (on the first screen) and a year by year comparison of the coal-based fuel costs or the heavy-oil fuel costs (Figure 41). The next screen summarizes the assumptions of the analysis (as shown previously in Figure 39). The next screen shows the present value cost comparison, investment costs, coal costs, and heavy-oil costs, as shown in Figure 42. If the coal-based retrofit costs are less than the heavy-oil energy costs, the line summarizing the net value is the cost savings that was calculated for implementing the retrofit. If it is more, the last line is the cost penalty—the present value of the extra expense in implementing the retrofit.

Central Heat Plant Economic Evaluation Program
12/01/92
Facility Financial Statement
Retrofit Plant (RT)

Year	Adjusted Investment	Coal-based Energy Costs	Heavy Oil Energy Costs
1990	4,635,000		
1991	2,874,158	9,327,016	
1992	2,878,943	8,645,198	
1993	2,883,729	8,003,096	
1994	2,888,515	7,413,952	
1995	2,893,338	6,871,145	
1996	2,898,124	6,368,055	
1997	2,902,947	5,898,064	
1998	2,907,771	5,461,170	
1999	2,912,632	5,063,994	
2000	2,917,455	4,686,677	
2001	2,922,316	4,342,458	
2002	2,927,177	4,024,717	
2003	2,932,076	3,726,835	
2004	2,936,937	3,455,431	
2005	2,941,836	3,197,267	
2006	2,946,735	2,965,581	

Press any key to continue...

Figure 41. Yearly cash flow display for retrofit plant-cost model.

```
Central Heat Plant Economic Evaluation Program
12/01/92
Facility Financial Statement
Retrofit Plant (RT)

FUEL COST COMPARISON:
    PV 'Adjusted' Investment Costs = $  3,830,579
    + PV Coal-related Energy/Transportation costs = $21,831,218
    - PV Heavy Oil Energy Costs  = $  43,804,356
----------------------------------------------------------
    Cost Savings for Retrofit (1988) = $  18,142,560
    Print report? (Y/N)  N
```

Figure 42. Cost savings/penalty display for retrofit case.

Cost Model Report Printing

At this point, CHPECON asks if you want a report printed from this cost model run. The report is a reiteration of the inputs and values entered previously in the screening model, the summaries, and a more detailed breakdown of the costs in each area. If the report is to be printed, CHPECON starts immediately. When finished printing, or if a printed report is not desired, CHPECON returns to the cost model main menu. A sample cost model output is presented in Appendix B.

Central Heat Plant Salvage Value

Background

Salvage value is an element of the life cycle costing economic model, and is included in the CHPECON program. Salvage values can, under certain circumstances, have a significant impact on the cost effectiveness of replacing an older central heat plant facility with a new facility. Thus, more accurate economic analyses can be performed with improved knowledge of salvage values, leading to more consistent and reliable decisions.

Salvage value is defined as the net amount of money obtainable from the sale of used property over and above any charges involved in removal and sale. Although the term implies that an asset can provide some type of further service, this is not necessarily the case. Often, used property will not provide further service because it does not realize any demand in resale markets, has lost its economic value due to technical obsolescence, or difficulty in dismantling. In this case, property is generally sold for *scrap value*, which is defined as material having no useful value remaining in its current state. The typical use of scrap is in manufacturing raw material. The costs

of dismantling and disposing of property, which can be very substantial, must be factored into the salvage value. The term *net salvage value* is often used to connote the combined effect of these factors, and can be a positive or negative value.

Two types of salvage value are possible in the analysis of central heat plant reconstruction. First, removal of the existing heat plant equipment will generate an immediate salvage value, positive or negative. Second, construction of the new heat plant facility will cause a salvage value to be created at the end of the new facility's life—25, 30, or maybe 40 years in the future. Salvage value, scrap value, and service life are usually estimated on the basis of conditions at the time the property is put into use. These factors are difficult to predict with any degree of accuracy, and typically represent the most uncertain factors in a life cycle costing economic analysis.

New Plant Salvage Value

The salvage value for a new plant is extremely difficult to predict, due to the unknown conditions in the future such as resale markets, scrap material value, equipment technical viability, and dismantling and removal costs. Fortunately, the salvage value of the new plant has a negligible impact on facility life cycle cost because the present value of cash flows occurring far in the future is minimal. (The present value of distant cash flows is affected, of course, by the discount rate used in the analysis.) For this reason, textbooks on economics and cost estimating frequently encourage practitioners to specify a new plant salvage value of zero. Although this has been described as a state of "total ignorance," a zero new plant salvage value is extremely reasonable in the absence of any special information. Although much effort could be devoted to developing "better" estimates for new plant salvage, the discounting process makes any adjustments above or below zero virtually inconsequential for most analyses.

Existing Plant Salvage Value

The salvage value of the existing heat plant has a much more important effect on the life cycle cost analysis because it is undiscounted, i.e., the cash flow occurs immediately. Thus, more accurate estimates of existing plant salvage value can often lead to more reliable representations of project economic attractiveness. For this reason, a detailed and site-specific analysis of existing plant salvage value is generally recommended for large projects.

Presently, there is virtually no resale value for used power plant equipment, for several reasons. First, very few fossil fuel power plants are ever retired; most plants are simply refurbished on a continuing basis. This severely limits the supply of used

equipment. Second, most new plants are constructed without considering the option of purchasing used equipment. This hinders the emergence of local secondary markets, thus preventing any sizeable demand for used equipment. Finally, the active market for scrap materials is a more practical and readily available alternative for disposal of used equipment. Scrap materials experience a relatively consistent demand in an active secondary market.

Despite the lack of a viable resale market, certain heat plant items do show promise for continued use after retirement. The items most likely to have some value for continuing use include the following:

- Circulating water pumps,
- Boiler electric forced circulation pumps,
- Draft fans,
- Stacker-reclaimers,
- Coal crushers,
- Ball mills,
- Coal feeders,
- Pulverizers, and
- Auxiliary boilers.

Salvage values for plant equipment may be related to the age of the plant. The physical deterioration and technical obsolescence of equipment certainly increase with age. In addition, the location of the plant, type of fuel used, and size of the plant may affect salvage values. One factor that was identified as being extremely important to dismantling costs is the existence of hazardous materials, particularly asbestos. Industry experts have indicated that asbestos removal can introduce even greater variability into plant dismantling costs. In fact, the existence of asbestos in central heat plants and steam distribution systems can double the cost of dismantling. A comprehensive site investigation for hazardous materials is strongly recommended in order to develop an accurate estimate of removal and dismantling costs.

Salvage Value As Used In Accounting Techniques

A life cycle costing analysis requires recognition that physical assets decrease in value with age. Decreases in value may be due to physical deterioration, technological advances, economic changes or other factors that ultimately will cause retirement of the property. Reductions in property value are measured by *depreciation* for purposes of tax accounting. Depreciation represents an annual charge against earnings over a given period for recovery of invested capital. Unfortunately, depreciation does not have any relation to the economic value of the property, nor is depreciation necessarily

meaningful for government facility operations. Furthermore, depreciation for tax accounting purposes requires an estimate of final salvage value as an input to the calculation, not as an output. In short, depreciation cannot be used as a basis for computing the economic salvage value of government-owned central heat plants. The economic salvage value is the actual cash amount that will be provided (or required) at the time of plant retirement.

Estimating Economic Salvage Value

In most cases, plant dismantling costs will exceed scrap/salvage credits. Thus, the net salvage value will be negative in many cases. Given the difficulty in determining realistic salvage credits, scrap credits are easier to estimate because active markets exist for scrap materials. Prices for scrap materials vary somewhat between local markets, but 1992 average prices for the three most valuable scrap materials are listed below.

- Copper: $0.43/lb,
- Stainless Steel: $460/gross ton, and
- Carbon Steel: $65/gross ton.

In the absence of facility information that provides the necessary level of detail, estimating existing plant salvage value is exceedingly difficult. Many factors affect the salvage value, including the age and condition of the plant, the local scrap and salvage markets, labor rates, the necessity to prepare the site for other purposes subsequent to facility retirement, and the existence of any hazardous materials or conditions that must be remediated. Without such information, any estimate must be issued with a very low degree of confidence.

Procedure For Estimating Salvage Value With CHPECON

The CHPECON program allows you to enter any salvage value amount for the existing plant. As discussed previously, the recommended value for the new plant salvage value is zero. A recommended value for the existing plant salvage is more difficult to determine. Lacking any information to the contrary, the program to uses as a default an existing plant salvage value of zero. However, one method has been developed to assist you in estimating the existing plant salvage value.

This method begins with the recognition that you could determine the *present* cost of building a facility similar to the existing central heat plant by running the CHPECON program for the appropriate plant size and technology. Dismantling costs are expected to be highly correlated with the installation labor of constructing the facility, while

scrap and salvage credits should be correlated with the material and equipment costs. Dismantling labor costs are expected to represent 50 percent of the installation costs of constructing a new facility. Management and engineering costs are expected to account for an additional 10 percent, for a total dismantling cost of 60 percent of the installation costs of facility construction. Scrap credits and salvage credits are expected to represent 5 percent of equipment and material costs of new facility construction for central heat plants. The presence of cogeneration equipment at the existing facility will increase scrap and salvage credits by an additional 2 percent, for a total scrap/salvage credit of 7 percent at cogeneration facilities. This is due to the relatively higher percentage of usable scrap metal, such as copper, in generators. Thus, total net salvage value can be derived by adding scrap credits and salvage credits, and subtracting dismantling labor and management costs.

This method represents a reasonable approximation of expected dismantling costs and credits for a generic facility. This method is inferior to a site evaluation by dismantling specialists. Furthermore, important effects such as plant age and condition, local markets for scrap and used equipment, and the existence of hazardous materials are not explicitly considered in this approximation technique.

5 Multiple Run Analysis

The multiple run analysis option performs the costing model for all appropriate coal technologies, based on the input entries from a single screening model data file. Results of the analysis are presented with each technology and coalfield combination sorted in order of increasing life cycle costs.

Functional Description of Implementation

After some experience with CHPECON, it was determined that a form of automated analysis was the only realistic method to comprehensively evaluate the possible boiler technology and coalfield combinations for a large number of different sites. Although it would be feasible to manually work through each combination, the amount of time required to run the program and manually collate the results was considered prohibitive. As a result, the ability to automate the sizing and costing of boiler facilities for a given military base was added to the CHPECON program in this task.

The multiple run analysis option requires that a screening model case already exist for the military base to be studied. This ensures that the basic information about the facility is present—heating load requirements, location, and type of system. This also allows you to have answered the general questions about availability of auxiliary facilities (such as water and sewer lines) that are common for any boiler facility.

When first started, the option runs an analysis with oil/gas boilers, using the default characteristics for these fuels. It also evaluates the coal-water and coal-oil slurry boiler technologies, since these use processed fuels, delivered in a fashion similar to fuel oil, and are not directly dependent on having a coalfield with the right fuel properties in close proximity to the base. After this, the program goes to the top of the file containing coalfield information, selecting the first coalfield. It then sequentially steps through the coal-fired boiler technologies. For each technology, the option checks the allowable parameters database file to determine whether boilers based on the current technology can use the coal from the currently selected coalfield. If the technology and coalfield are not compatible, the program advances to the next technology.

If the technology is compatible with the coalfield, the program continues its analysis. New boiler sizing is selected based on the previously entered load and calculated PMCR data. The option defaults to selecting four boilers (as was initially recommended by USACERL to ensure high reliability). If the formulas for four boilers produce sizes that are outside the limits of the technology, three boilers and five boilers are tried to see whether one of the configurations is feasible. If neither of these configurations produce boiler sizes compatible with the technology, the program skips any further evaluation and moves on to the next technology.

If the technology is compatible with the coalfield properties, and the boilers can be sized for the plant's PMCR and remain in the acceptable bounds of the technology, the program continues with the analysis. It computes the life cycle cost for the facility, using default answers for each of the questions that normally appear when conducting a cost model analysis. The overall cost of the facility is then stored in the report file.

At the end of each technology sequence, the program advances to the next coalfield, and begins the technology cycle again. A total of three files are created during the multiple run analysis. Two are temporary files that are given a unique filename with the default extension ".DBF" and are deleted at the end of the process. However, adequate room on the hard disk is needed to establish them even though they are later removed. The actual size needed depends on the operating parameters selected for the multiple run analysis. The worst case would be 3k for the one file, and 680k for the other (the size of the coalfield database).

A temporary file is generated to hold the information from the screening model. The multiple run option has been written to draw on the information from the screening model case that has been stored to gain the information necessary to provide a comprehensive evaluation. This file is modified with the new parameters based on each of the coalfield and boiler technology combinations. It is then used for the costing model to determine the life cycle cost for each combination.

A second temporary file contains a copy of the information on coalfields within a user-selected distance of the military base. If the range you select is large enough, the entire coalfield database can be selected to evaluate its potential. This temporary file differs from the coalfield in that it is accessed in order of increasing distance from the military base. This means that the closest coalfields are evaluated first.

A third file is created to contain the results of the multiple run analysis, and is given the same name as the file containing the screening model with an extension of "@MR". Unlike the other two files, this file remains after the analysis is completed, until the user manually deletes it from the working directory.

User Interface

A series of menus guide you through the necessary questions to complete an analysis. The initial screen for CHPECON (as shown in Figure 43) reflects the options to access the multiple run analysis.

```
Central Heating Plant Economics Evaluation Program 08/01/92
Main Menu

1 -- Screening Models              6 -- Update Databases

2 -- Cost Models                   7 -- System Utilities

3 -- Multiple Run Analysis

4 -- Sensitivity Analysis

5 -- Load Sensitivity Analysis     Q -- Quit (exit program)


Use ↑↓ to move highlight or enter first character to select option
```

Figure 43. Initial menu screen for CHPECON.

Once the multiple run analysis option is selected, the menu in Figure 44 is shown, allowing you to run any new plant multiple run analysis or print existing reports. The Quit option returns you to the previous CHPECON main menu.

```
Central Heating Plant Economics Evaluation Program 08/01/92
Main menu -- multiple runs

1 -- New plant
2 -- New plant with cogeneration
3 -- New plant with third-party cogeneration
4 -- New plant with consolidation
P -- Print report
Q -- Quit (return to main menu)

Use ↑↓ to move highlight or enter first character to select option
```

Figure 44. Menu screen for multiple run analysis.

After selecting the particular type of system to be considered in the multiple run analysis, the list of available screening model data files is shown. Once you make a selection, the program proceeds to the coal range selection screen, as shown in Figure 45. You must indicate the maximum distance that a coalfield can be from the facility site (calculated based on latitude and longitude) to be considered a candidate

for the multiple run analysis. This feature allows you to limit the number of coalfields being considered. If all coalfields should be considered as potential candidates, a value of all nines (9999) should be entered, because no coalfield is more distant for continental United States sites. While scanning the coalfield database, the program informs you of the number of selected coalfields and their types (e.g., bituminous).

```
              Coalfields are identified as possible candidates based on
              proximity to the selected base, and on properties that are
                  compatible with the selected boiler technology.

Distance from base to include:  250 miles

Fields searched:  2428        selected: 133

    anthracite:      0       lignite:   0
    bituminous:    133   sub-bituminous: 0


Search with a different distance? (Y/N) Y
```

Figure 45. Coal range selection screen.

After selecting a suitable distance for coalfield inclusion, the system asks for confirmation to proceed with the analysis. Once confirmed, the program begins the analysis portion of the multiple run analysis. The program displays the screen as shown in Figure 46 to inform you of the progress being made in the analysis. It follows the logic described above, through the coalfields, and through the coal technologies for each field.

```
Using coalfield # 89 of 133

Using boiler technology # 3
```

Figure 46. Progress display for multiple run analysis.

After completing the multiple run analysis with the screening model data and the range of coalfields, the program returns to the menu for the multiple run analysis (Figure 44).

The reports that have been generated and stored can be accessed for printing through the *Print report* option of the multiple run analysis menu. Once selected, CHPECON displays the screen shown in Figure 47. A selection is made by moving the highlighting bar with the <Up> and <Down> keys to the desired file, and pressing the <+> key

to mark it. Pressing the <-> key unmarks a file for printing. Marking more than one files allows you to print multiple files from one selection screen. Once the desired files are marked, press <Enter> to cause the program to print the report files. Printing can be done to either the printer or ASCII text files. If printing to ASCII text files, the file name is the same as the analysis file, with the extension ".$MR". If no files are selected, the system asks you to confirm that no printing is requested, then either continues or returns to the menu based on the answer.

```
P --File--  Rpt Type  Description
   --- top of list ---
 6407CG     || ||  NAS WHITING FLD MILTON
 6407NP     || ||  NAS WHITING FLD MILTON
 6432CG06   || ||  NAS WHITING FLD MILTON
 6432CGNG   || ||  NAS WHITING FLD MILTON
 CG1        || ||  joliet army ammunition plant
 NP1        || ||  joliet army ammunition plant


      ↑↓ to move highlight
      +/- to select/unselect report, <ENTER> to print
```

Figure 47. File selection and printing screen.

Review of Output

An example of the output from the multiple run analysis option is shown in Table 2. It consists of the basic details about the coalfield, in order to locate it properly. It also includes the type of technology considered, the number of boilers that were determined for the site, the year for the calculations of the life cycle cost, and the end results: the life cycle cost and capital cost for a facility with the technology and coalfield. The listing is sorted in order of increasing life cycle cost, i.e., the lowest LCCs will show up first on the printout.

Table 2. Example of multiple run analysis output.

Coal state: IN	County: CLAY
Location: STRIP	
Latitude: 392531	Longitude: 870552 Distance from base: 153
Rank: B	Code No: W192632
Comment:	
Boiler type: 1 -- Dump Grate Spreader Stoker, w/ fly ash reinjection	
Number of boilers: 4	LCC Year: 1991
LCC: 137,127,960	Capital cost: 69,209,387
Coal state: IN	County: CLAY
Location: STRIP	
Latitude: 392531	Longitude: 870552 Distance from base: 153
Rank: B	Code No: W192632
Comment:	
Boiler type: 2 -- Dump Grate Spreader Stoker, w/o fly ash reinjection	
Number of boilers: 4	LCC Year: 1991
LCC: 137,127,960	Capital cost: 69,209,387
Coal state: IN	County: CLAY
Location: STRIP	
Latitude: 392531	Longitude: 870552 Distance from base: 153
Rank: B	Code No: W192632
Comment:	
Boiler type: 3 -- Vibrating Grate Spreader Stoker, w/ fly ash reinjection	
Number of boilers: 4	LCC Year: 1991
LCC: 137,127,960	Capital cost: 69,209,387

6 Sensitivity Analysis

This segment of the program performs a sensitivity analysis on various cost aspects by using specific program modules, as discussed below. The sensitivity analysis will allow you to understand the effects that changes to one variable have on the base case economic analysis of a given central heat plant. The analysis is also helpful in determining the areas in which cost or efficiency improvements would yield the most beneficial effects on life cycle cost.

The major cost categories included in the sensitivity analysis are:

- Capital costs,
- Primary fuel costs,
- Auxiliary energy costs,
- Operating and maintenance costs - labor portion,
- Operating and maintenance costs - nonlabor portion,
- Major repair and replacement costs, and
- Electricity cost credit (for cogeneration).

Variations based on coal selection are included in the Multiple Run Capability section of the program.

In addition to the above costs, the discount rate, existing plant salvage and new plant salvage are also analyzed in terms of their sensitivity. To produce the sensitivity analysis, an additional series of calculations are performed at the end of the standard cost analysis section, adjusting one or more values and determining the effect of the changes on the life cycle cost and levelized cost of service.

Functional Description of Implementation

The basic approach for implementing the Sensitivity Analysis section of the program is to complete a cost analysis on a particular screening model case and then vary the major factors that make up the life cycle cost and recompute the life cycle cost based on the modified values. Once the costs for every year of operation are known, they can be varied and a new life cycle cost calculated based on the modified values.

In the modified cost model (which is executed for this option), each cost for a given year of operation is stored in an array. The sensitivity analysis report includes the same information as for the general cost model at this point.

To determine the life cycle cost for the changes that result from the sensitivity analysis, the present value of each year's cost is first calculated by the following:

$$\text{Present\_value} = \text{Future\_value} / (1 + \text{discount\_rate})^{\text{years}}$$

The present value of each year's operating costs is then summed to produce a total, and the salvage values and investment costs are added:

Life cycle cost =

PV_Investment + PV_old_plant_salvage
+ PV_new_plant_salvage
+ PV_Primary_fuel_cost_year_1
+ PV_Auxiliary_energy_cost_year_1
+ PV_O&M_labor_year_1
+ PV_O&M_non_capital_non_labor_year_1
+ PV_O&M_capital_related_non_labor_year_1
+ PV_major_repair_replacement_year_1
.....
+ PV_Primary_fuel_cost_year_n
+ PV_Auxiliary_energy_cost_year_n
+ PV_O&M_labor_year_n
+ PV_O&M_non_capital_non_labor_year_n
+ PV_O&M_capital_related_non_labor_year_n
+ PV_major_repair_replacement_year_n.

The levelized cost of service is calculated from the life cycle cost and the total energy delivered by the following:

$$\text{LCS} = \text{LCC} * (i * (1+i)^{l}) / ((1+i)^{l} - 1) / d$$

where:
i = annual interest or discount rate, percent
l = life of facility, years, and
d = annual steam delivered.

Practical limits have been established for the range of the variations applied to the costs. The lowest minimum value that can be selected is 1 percent of the cost, and the highest minimum value that can be selected is 100 percent of the cost. An acceptable

step size is programmed to be at least 1 percent and no more than 50 percent, allowing at least one step, and two steps for a wide range of limits. The lowest maximum value that can be selected is 100 percent of the cost, and the highest maximum value is 1000 percent. Placing these limits ensures that the initially calculated costs are included as part of the analysis, and that some limits are in place. When the type of variation is not formulated on 100 percent as the baseline case (e.g., discount rate variation), the programmed limits are adjusted, as described below.

Functional or logical limits are represented by the default values that are accessed each time you run a sensitivity analysis. These are shown in Table 3.

Table 3. Original default values for sensitivity analysis.

	Min value*	Step value*	Max value*
Primary fuel cost variation:	80	10	120
Auxiliary energy cost variation:	80	10	120
O&M labor cost variation:	80	10	120
O&M non-labor cost variation:	80	10	120
Repair/replace cost variation:	80	10	120
Initial cost variation:	80	10	120
Existing salvage value variation:	-100	50	200
New salvage value variation:	-15	5	15
Discount rate variation:	0.0	1.0	12
Primary fuel escalation rate:	-3	1	6
Plant life variation:	10 yr	1 yr	25 yr

*Values are in percent unless stated otherwise.

Underlying the selection of practical limits for each of the parameters varied is the concept of "constant dollars," as described in the *Life-Cycle Cost Manual for the Federal Energy Management Program*. This concept assumes that most future prices will vary in accordance with the general rate of inflation; future dollars will have the same equivalent purchasing power. Because the CHPECON program was written so the rate of inflation is removed from the calculations through the use of constant dollars, the variations that may be seen for the various parameters are due to real changes, such as fuel or manpower availability or new technology.

For the Primary fuel cost variation, Auxiliary energy cost variation, O&M labor cost variation, O&M nonlabor cost variation, Repair/replace cost variation, and Initial cost variation, the range of variation of 80 to 120 percent was selected because historically the variations have been in this range. For the primary fuel and auxiliary energy

costs, the initial values are calculated from the Life Cycle Cost in Design (LCCID) energy cost data as provided by USACERL.

For the Existing salvage value variation, the recommended limits are -100 to 200 percent to accommodate the possibility of the salvage operation requiring an outlay of funds to dispose of the existing property, and to allow an underestimation of the salvage value. This requires that you enter an existing salvage value for the analysis to use as the baseline. The programmed limits for the minimum are -100 to 0 percent, and the maximum limits are 0 percent to 200 percent, with a step size of from 1 percent to 50 percent.

For the New salvage value variation, the recommended limits are from -15 to 15 percent. This analysis uses the cost of the new facility and applies the variation to determine the salvage value at the end of the new facility's life. The programmed limits for the minimum are from -15 to 0 percent, and the maximum limits are from 0 to 15 percent, with a step size of from 1 to 5 percent.

For the Discount rate variation, the variation directly affects the discount rate used to calculate the life cycle cost. This variation differs from the previous values because it does not modify another cost, but is applied directly to all costs. The recommended minimum value is 0 percent, because a negative value would imply that a lender was willing to pay a borrower for the opportunity to establish a loan with the borrower. The 12 percent recommended upper limit is a value that has historically not been approached in the United States. The programmed limits for the minimum are from 0 percent to the default discount rate used by the program, and the maximum limits are from the default discount rate to 20 percent, with a minimum step size of 0.1 percent.

For the Primary fuel escalation rate, the default values are -3 to 6 percent. This allows the variation of the primary fuel cost to increase from 3 percent slower per year to 6 percent faster per year than the costs indicated by the LCCID fuel cost data. The programmed limits for the minimum are from -3 to 0 percent; the maximum limits are from 0 to 6 percent, with a step size of from 1 to 3 percent.

For the Plant life variation, the minimum and maximum suggested values are 10 years to 25 years. The minimum was selected because it is normally not considered practical or logical to invest in a facility and use it for one-third or less of its useful life. The maximum of 25 years is a prescribed limit by the provisions of the Energy Security Act of 1980. The programmed limits for the minimum are from 10 to 24 years, and the maximum limits are from the minimum plus the step years to 25 years. The step size

must be at least 1 year and no more than the difference between 25 years and the minimum.

Special handling was required to adjust the nonlabor operating and maintenance costs because they are composed of two separate costs; a nonlabor portion not related to initial costs, and a nonlabor portion that is proportional to initial costs. The proportional set of costs needed to be adjusted when the capital costs were adjusted (as a result of the new initial costs), while the others were held constant.

Two permanent files are created to contain the results of the sensitivity analysis. These files are given the same name as the screening model with an extension of "@SL" for files containing the long form of the sensitivity analysis report, and "@SS" for files containing the short form of the sensitivity analysis report. These files remain in the working directory after the analysis is completed, until you manually delete them.

The program implementation of the sensitivity analysis uses the minimum and maximum limits as noted above. The step value that must be specified for each of the parameters must be positive to effect the move from the minimum to the maximum values.

When running, the program will pause after the cost model is completed to allow you to adjust the minimum, step, and maximum values for each of the variations implemented in the sensitivity analysis. When changing the values, the program will automatically adjust the values if allowable limits are exceeded.

The printing functions operate in a similar fashion to the other segments of CHPECON. When you select an option, the system displays a list of files for that format. Once you highlight the files to be printed, the program proceeds to printing.

You can change the default minimum, step, and maximum values (those that are displayed when the screen is first shown in a sensitivity analysis run) under the system utility option. Once selected, the same screen as that after the cost model segment is shown, for you to enter the default values.

Additional program modules were written for the graphical display of the results. In addition, a database file, GRPHDATA.@$@, is created to hold the calculated results, which are then used by the graphics modules.

User Interface

A series of menus guide you through the necessary questions to complete an analysis. The initial screen for CHPECON (Figure 48) reflects the option to access the sensitivity analysis.

```
Central Heating Plant Economics Evaluation Program 08/01/92
Main Menu

1 -- Screening Models                  6 -- Update Databases
2 -- Cost Models                       7 -- System Utilities
3 -- Multiple Run Analysis
4 -- Sensitivity Analysis
5 -- Load Sensitivity Analysis         Q -- Quit (exit program)

Use ↑↓ to move highlight or enter first character to select option
------------------------------------------------------------------------------
```

Figure 48. Initial menu screen for CHPECON.

Once you select the sensitivity analysis option, the system displays the menu shown in Figure 49, allowing you to run any new plant sensitivity analysis or print existing reports. The Quit option returns you to the previous CHPECON main menu.

```
Central Heating Plant Economics Evaluation Program 08/01/92
Main menu -- sensitivity analysis

1 -- New plant
2 -- New plant with cogeneration
3 -- New plant with third-party cogeneration
4 -- New plant with consolidation
P -- Print report
Q -- Quit (return to main menu)

Use ↑↓ to move highlight or enter first character to select option
------------------------------------------------------------------------------
```

Figure 49. Menu screen for sensitivity analysis.

The cost analysis is called after indicating which screening model file should be used for analysis. After completing the cost model analysis, CHPECON presents the screen

shown in Figure 50. You can enter alternate values for the minimum, step, and maximum values for each of the varied parameters. Once the values are set (indicated by accepting the values shown), the system performs the sensitivity analysis. As this occurs, the lower portion of the screen is used to indicate the progress of the program, by displaying the parameter being varied and the currently used factor.

Central Heating Plant Economics Evaluation Program 08/01/92
Facility Financial Statement New plant (NP)

	Min value	Step value	Max value
Primary fuel cost variation:	80%	10%	120%
Auxiliary energy cost variation:	80%	10%	120%
O&M labor cost variation:	80%	10%	120%
O&M non-labor cost variation:	80%	10%	120%
Repair/replace cost variation:	80%	10%	120%
Initial cost variation:	80%	10%	120%
Existing salvage value variation:	-100%	50%	200%
New salvage value variation:	-15%	5%	15%
Discount rate variation:	0.0%	1.0%	12.0%
Primary fuel escalation rate:	-3%	1%	6%
Plant life variation:	10 yr	1 yr	25 yr

Accept / Change values? (A/C) «A»

Figure 50. Parameter variation screen for sensitivity analysis.

After the sensitivity analysis is completed, you are presented with the option of printing the Short format report, the Long format report, Both formats, or None. After performing any necessary printing, the program returns to the sensitivity analysis menu.

The information can be reviewed graphically on screen. The system must be equipped with an EGA- or VGA-compatible monitor to show the graphics screens. After completing the sensitivity analysis, the system shows the screen in Figure 51. From this, you can view a graphic of the effect on life cycle cost for one of the parameters. As with other menus, using the <Up> and <Down> keys moves the highlight bar to select an option, which is then executed by pressing the <Enter> key. Alternatively, pressing the letter key that is highlighted on the menu options automatically selects and executes the option. Parameters that are not available are shown in a shadowed color.

Primary fuel cost variation
Auxiliary energy cost variation
O&M labor cost variation
O&M non-labor cost variation
Repair/replace cost variation
Initial cost variation
Composite cost variation
Existing plant salvage value
New salvage value
Discount rate
Primary fuel escalation rate
Site/plant life

Quit

Select parameter to view graphically, or Quit to continue
For graphics print, press 'P' for Postscript, 'L' for LaserJet
Press any key to return here from graphics display

Figure 51. Sensitivity analysis graphical presentation selection screen.

An additional option is a composite presentation of the first six parameters. The definition of the variations and their computations are similar and can be directly compared on the same graph (i.e., the X-axis scale is compatible).

Once you select a particular option, CHPECON switches to the graphics display mode and presents the results. It switches back to the menu after you press a key.

The graph that is displayed can be printed to either a Postscript printer or a LaserJet-compatible printer connected to parallel port LPT1 by pressing "P" or "L", respectively, when the graph is displayed.

The reports that have been generated and stored can be accessed for printing through the Print report option of the sensitivity analysis menu. The screen in Figure 52 is first displayed, allowing you to indicate if the Short format, Long format, or Both types of reports should be displayed for selection. Once the type of report is indicated, CHPECON displays the screen shown in Figure 53. On screen, the type of report (long [L] or short [S]) is indicated in the column headed Rpt. The type of screening model that was the basis for the analysis is indicated in the column headed Type: NP for new plants, CG for cogeneration new plants, TP for third party cogeneration, and CN for consolidation-based new plants.

```
Central Heating Plant Economics Evaluation Program 08/01/92
Sensitivity analysis -- report selection for printing
      Display

          Long format sensitivity analysis reports
          Short format sensitivity analysis reports
          Both long and short format reports
           for print selection

Use ↑↓ to move highlight or enter first character to select option
```

Figure 52. Sensitivity analysis report type selection.

```
P --File--  Rpt Type  Description
   --- top of list ---
 6432NP06    ‖ L ‖ NP  ‖ NAS WHITING FLD MILTON ■ Gas / Oil Fired Boiler
 6432NP06    ‖ S ‖ NP  ‖ NAS WHITING FLD MILTON ■ Gas / Oil Fired Boiler
 6432NPNG    ‖ L ‖ NP  ‖ NAS WHITING FLD MILTON ■ Gas / Oil Fired Boiler
 6432NPNG    ‖ S ‖ NP  ‖ NAS WHITING FLD MILTON ■ Gas / Oil Fired Boiler
 NP1         ‖ L ‖ NP  ‖ joliet army ammunition plant ■ Dump Grate Spreader Stoke
 NP1         ‖ S ‖ NP  ‖ joliet army ammunition plant ■ Dump Grate Spreader Stoke
 PICA01      ‖ L ‖ NP  ‖ Picatinny Arsenal ■ Dump Grate Spreader Stoker, w/ fly a
 PICA01      ‖ S ‖ NP  ‖ Picatinny Arsenal ■ Dump Grate Spreader Stoker, w/ fly a
 PICANP      ‖ L ‖ NP  ‖ Picatinny Arsenal ■ Coal-Oil Slurry
 PICANP      ‖ S ‖ NP  ‖ Picatinny Arsenal ■ Coal-Oil Slurry

      ↑↓ to move highlight
      +/- to select/unselect report, <ENTER> to print
```

Figure 53. Sensitivity analysis report selection for printing.

Make a selection by moving the highlighting bar with the <Up> and <Down> keys to the desired file, and pressing the <+> key to mark it. Pressing the <-> key unmarks a file for printing. Marking more than one file allows you to print multiple files from one selection screen. Once you have marked the desired files, pressing <Enter> will cause the program to print the report files. Printing can be output to either the printer or ASCII text files. If printed to an ASCII text file, the file name is the same as the analysis file, with the extension ".$LS". If no files are selected, the system asks you to confirm that printing is not requested, then either continues or returns to the menu based on the answer.

Review of Output

To describe the results of the sensitivity analysis on life cycle cost and the levelized cost of service (LCS), a case using information about Picatinny Arsenal was used. The facility uses dump grate spreader stoker boilers, operating with fly ash reinjection.

Table 4 contains the summary of the basic life cycle cost analysis from the CHPECON program, and is the basis for the following discussion.

Table 4. Life cycle cost summary base case values for sensitivity analysis examples.

Picatinny Arsenal -- Dump Grate Spreader Stoker, w/ fly ash reinjection		
+ PV 'Adjusted' Investment Costs	=	$ 62,527,563
+ PV Energy + Transportation Costs	=	$ 39,269,979
+ PV Annually Recurring O&M Costs	=	$ 31,904,416
+ PV Non-Annually Recurring Repair & Replacement	=	$ 2,487,293
- PV Salvage Value of Existing System	=	$ 873,785
- PV Salvage Value of New/Retrofit Facility	=	$ 1,019,898
Total Life Cycle Cost (1988)	=	$ 134,295,569
Levelized Cost of Service (1992 start) = 11.635 $/MMBtu		
Levelized Cost of Service (1992 start) = 13.911 $/1000 lb steam		

Primary Fuel Initial Cost

The primary fuel cost is the most substantial on-going cost of the boiler facility. It typically represents the largest annual operating cost, and thus plays a major part in the overall life cycle cost of the plant.

Varying the primary fuel's initial cost consists of adjusting each year's operating cost by the amount defined in the sensitivity analysis. For example, to study the effect of an initial cost of the primary fuel that is 20 percent less than the value used by the cost model, the cost stored for each year would be reduced to 80 percent of its value. This is the equivalent of reducing the initial cost by 20 percent and then calculating the outlying years based on the standard fuel escalation rates. Table 5 shows the effect of varying the primary fuel initial cost.

Table 5. Example of primary fuel initial cost variation.

Change (percent)	PV Primary Fuel	Life Cycle Cost	LCS ($/1000lb steam)
80	28,130,607	127,262,917	13.183
90	31,646,933	130,779,243	13.547
100	35,163,259	134,295,569	13.911
110	38,679,585	137,811,895	14.275
120	42,195,911	141,328,221	14.640

Primary Fuel Escalation Rate

Varying the primary fuel escalation rate consists of adjusting each year's operating cost by the amount defined in the sensitivity analysis, compounded over the years of operation. For example, to study the effect of a 3 percent decrease in the escalation rate of the primary fuel, the cost stored for each year would be reduced to 0.97^n of its value, where n is the operating year. For the first year, the cost would be reduced by 3 percent; the second year would see a reduction of 3^2 percent, to 0.9409 of the initial value; and so on. Varying the escalation rate simulates the effect of a lower than expected rate of cost increase (with respect to inflation). The primary fuel escalation rate variation can also be thought of as an adjustment to the energy escalation rates that are contained in the program. These energy escalation rates are specified by the U.S. Department of Energy, and are incorporated into CHPECON through a link to the LCCID program.

The variation allowed for the escalation rate is from a reduction of 3 percent to an increase of 6 percent. The effect of varying the primary fuel escalation rate is shown in Table 6 for the Picatinny example.

Table 6. Example of primary fuel escalation rate variation.

Change (percent)	PV Primary Fuel	Life Cycle Cost	LCS ($/1000lb steam)
-3	25,495,286	124,627,597	12.910
-2	28,268,878	127,401,188	13.197
-1	31,466,560	130,598,870	13.528
0	35,163,259	134,295,569	13.911
1	39,447,809	138,580,120	14.355
2	44,425,554	143,557,864	14.871
3	50,221,417	149,353,728	15.471
4	56,983,542	156,115,852	16.172
5	64,887,584	164,019,895	16.990
6	74,141,791	173,274,101	17.949

Auxiliary Energy Cost

Varying the auxiliary energy cost consists of adjusting each year's operating cost by the amount defined in the sensitivity analysis. For example, to study the effect of auxiliary energy costing 20 percent less than the value used by the cost model, the cost stored for each year would be reduced to 80 percent of its value. This adjustment is similar to the cost variation established for the primary fuel initial cost sensitivity.

For boilers that serve as cogeneration facilities, when the auxiliary energy cost is varied, the credit taken for the electricity that was generated is also increased or reduced by the same amount. The rationale for this is that the electricity credit should be less because the electricity that is offset, which would have been purchased, costs less. Table 7 shows the effect of varying auxiliary energy costs.

Table 7. Example of auxiliary energy cost variation.

Change (percent)	PV Aux. Energy	Life Cycle Cost	LCS($/1000lb steam)
80	3,285,376	133,474,225	13.826
90	3,696,048	133,884,897	13.869
100	4,106,720	134,295,569	13.911
110	4,517,392	134,706,241	13.954
120	4,928,064	135,116,913	13.996

Operating and Maintenance—Labor Portion

Operating and maintenance costs for each year are composed of a labor portion for the staff, a nonlabor, noncapital-related portion for materials and supplies, and a nonlabor portion that is proportional to the cost of various equipment. Varying the labor portion of O&M costs simulates a change to either salary rates or staffing levels (or a combination of the two). The implementation is to adjust each year's labor O&M by the fractional change. An example of the effect of this variation is shown in Table 8.

Table 8. Example of O&M labor cost variation.

Change (percent)	PV O&M Labor	Life Cycle Cost	LCS ($/1000lb steam)
80	12,332,318	131,212,489	13.592
90	13,873,858	132,754,029	13.752
100	15,415,398	134,295,569	13.911
110	16,956,938	135,837,109	14.071
120	18,498,478	137,378,649	14.231

Operating and Maintenance—Nonlabor Portion

The nonlabor portion of the operating and maintenance cost covers the materials, supplies, and maintenance that occurs on an annual basis for the facility. The procedure is to adjust each year's nonlabor O&M by the fractional change desired by the analysis. An example of the effect of this variation is shown in Table 9.

Table 9. Example of O&M nonlabor cost variation.

Change (percent)	PV O&M Nonlabor	Life Cycle Cost	LCS ($/1000lb steam)
80	13,191,214	130,997,766	13.570
90	14,840,116	132,646,667	13.740
100	16,489,018	134,295,569	13.911
110	18,137,920	135,944,471	14.082
120	19,786,821	137,593,373	14.253

Major Repair and Replacement Costs

Major repair and replacement costs are related to the nonannual expenses that occur every 2, 3, 5, or more years that are involved with major component maintenance. One example of this is the liner replacement required to maintain the efficiency of baghouses. Because the spacing of these costs is not regular, the approach of using an array of yearly values for each category of expense was adopted. This allows the program to properly calculate the sums of the present values for these costs. As for most of the other factors, the procedure is to adjust each year's nonlabor O&M by the fractional change desired by the analysis. An example of the effect of this variation is shown in Table 10.

Table 10. Example of repair/replace cost variation.

Change (percent)	PV Repair/Replace	Life Cycle Cost	LCS ($/1000lb steam)
80	1,989,834	133,798,110	13.860
90	2,238,564	134,046,840	13.885
100	2,487,293	134,295,569	13.911
110	2,736,022	134,544,299	13.937
120	2,984,752	134,793,028	13.963

Initial Cost

The initial cost of the facility consists of the capital, bulk material, freight, installation labor, indirect costs, engineering expenses, etc. Variation of the initial cost would affect the life-cycle cost directly and would not be a matter of concern if the variation affected only the initial capital cost component. However, one portion of the annual maintenance is computed as a fraction of the capital cost. Furthermore, the major repair and replacement costs are also computed as fractions of the capital costs for each component. In addition, a percentage of the new plant salvage value is linked to the initial capital cost, and therefore will be affected by changes to the capital cost. To study the effect of varying the initial cost, factors including the initial plant cost, the nonlabor capital-related O&M costs, major repair and replacements costs, and new

plant salvage value are all adjusted by the same amount, before calculating the life cycle cost of the facility. The recognition that changes in initial capital costs will affect future expenditures for capital-related items is beneficial to the accuracy of the sensitivity analysis. Table 11 shows the effect of varying the initial cost of the facility.

Table 11. Example of initial cost variation.

Change (percent)	PV Initial Cost	Life Cycle Cost	LCS ($/1000lb steam)
80	50,022,051	119,954,540	12.426
90	56,274,807	127,125,055	13.168
100	62,527,563	134,295,569	13.911
110	68,780,320	141,466,084	14.654
120	75,033,076	148,636,598	15.397

Existing Plant Salvage Value

Unlike the rest of the calculations in the cost model, you must enter the salvage value of the existing plant. Varying the amount of this entry affects the life cycle cost directly (i.e., the time value of money is not a consideration because the cash flow is occurring at time zero). A positive salvage value acts as a credit, reducing the life cycle cost. A negative value indicates that the existing plant will have a cost associated with its removal, and increases the life cycle cost.

The variation that is allowed for this cost/credit is from -100 to +200 percent. If no value for the existing salvage is entered, this part of the sensitivity analysis is skipped.

Table 12 shows the effect of changing the existing plant's salvage value. It directly adds to or subtracts from the life cycle cost.

Table 12. Example of existing plant salvage value variation.

Change (percent)	PV Existing Salvage	Life Cycle Cost	LCS ($/1000lb steam)
-100	-873,785	136,043,141	14.092
-50	-436,892	135,606,248	14.047
0	0	135,169,355	14.002
50	436,892	134,732,462	13.956
100	873,785	134,295,569	13.911
150	1,310,678	133,858,676	13.866
200	1,747,571	133,421,783	13.821

New Plant Salvage Value

The new plant potentially has some salvage value at the end of its operational life. This variation studies how that salvage value would affect the life cycle cost of the facility. When using the cost model, a percentage value is entered which is the fraction of the capital and bulk material costs of the facility that is expected to be received at the end. A positive percentage for the salvage value acts as a credit, reducing the life cycle cost, while a negative percentage indicates that the new plant will have a cost associated with its removal, and increases the life cycle cost.

The variation that is allowed for this cost/credit is from -15 percent of the facility's capital cost (an expense to remove) to +15 percent of the facility's capital cost. Table 13 shows the effect of changing the new plant's salvage value. It directly adds to or subtracts from the life cycle cost.

Table 13. Example of new plant salvage value variation.

Change (percent)	PV New Salvage	Life Cycle Cost	LCS ($/1000lb steam)
-15	-1,529,847	136,845,316	14.175
-10	-1,019,898	136,335,366	14.123
-5	-509,949	135,825,417	14.070
0	0	135,315,468	14.017
5	509,949	134,805,518	13.964
10	1,019,898	134,295,569	13.911
15	1,529,847	133,785,620	13.858

Discount Rate

The discount rate is a measure of the cost of money. The discount rate used in the CHPECON program represents a *real* interest rate, which indicates that an inflation premium is not included. The discount rate for use in Federal life cycle costing projects is published annually in Title 10, Part 436 of the Code of Federal Regulations, "Guidelines Applicable to Federal Agency In-house Energy Management Programs," subpart A, "Life Cycle Cost Methods and Procedures." The discount rate is the one variation that affects every cost, because it is the value used to calculate the present value of each year's cost. The discount rate variation that is allowed is from 0 to 20 percent. Negative discount rates are not allowed. The maximum value of 20 percent represents an upper limit that has never been surpassed in the United States.

The example in Table 14 shows the effect of varying the discount rate. Increasing the discount rate decreases the present value of project costs by weighting the distant

future cash flows less heavily. Decreasing the discount rate increases the present value of project costs by considering distant cash flows more heavily.

Table 14. Example of discount rate variation.

Change (percent)	Life Cycle Cost	LCS, $/1000lb steam
0.0	213,401,030	22.106
0.6	199,125,372	20.627
1.6	178,543,998	18.495
2.6	161,284,402	16.707
3.6	146,703,668	15.197
4.6	134,295,569	13.911
5.6	123,659,632	12.809
6.6	114,477,543	11.858
7.6	106,495,093	11.031
8.6	99,508,296	10.308
9.6	93,352,682	9.670
10.6	87,895,004	9.105
11.6	83,026,788	8.600
12.6	78,659,298	8.148
13.6	74,719,596	7.740
14.6	71,147,432	7.370
15.6	67,892,802	7.033
16.6	64,914,000	6.724
17.6	62,176,072	6.440
18.6	59,649,587	6.179
19.6	57,309,643	5.936
20.0	56,421,044	5.844

Changes to the discount rate will influence the relative importance of capital versus operating costs. For example, decreasing the discount rate will increase the relative importance of annually-occurring operating and maintenance costs in the life cycle cost analysis. However, capital and installation costs occur at the beginning of the plant's life, and the present value of these costs is relatively insensitive to changes in the discount rate. Thus, higher discount rates place an emphasis on capital costs, while lower discount rates consider operating and maintenance costs to a greater extent.

Plant Life

Variation in plant life shows the effect on life cycle cost of spreading the investment cost of the facility over a different number of years of operation. The minimum value for the plant life sensitivity is 10 years, with the maximum reaching a Federally-imposed limit of 25 years. Criteria regarding the treatment of facility lifetime can be found in *Energy Prices and Discount Factors for Life Cycle Cost Analysis: Annual Supplement to NBS (National Bureau of Standards) Handbook 135* and *NBS Special Publication 709*, published by the U.S. Department of Commerce, National Technical Information Service, NTIS IR 85-3273-5. The analysis is implemented by eliminating costs for years greater than the desired life, and calculating the life cycle cost on the remaining years of operation. This analysis is useful when considering the effects of unplanned service termination in future years, such as military base closings.

The effect of decreasing the expected lifetime of the facility can be seen in Table 15. A shorter lifetime produces a lower life cycle cost, because fewer years of fuel and nonfuel operating costs will have occurred. However, the levelized cost of service increases as the plant life decreases. This is due to the fact that the installed cost of the facility is averaged over a smaller total steam output from the facility, since the annual production is delivered for a lesser number of years. The extreme example would be a facility that was built and operated for just one pound of steam; the levelized cost of service would be the installed cost of the facility.

Table 15. Example of plant life variation.

Change (years)	Life Cycle Cost	LCS ($/1000lb steam)
10	96,932,586	18.716
11	100,008,290	17.922
12	103,060,194	17.281
13	105,907,914	16.731
14	108,701,830	16.271
15	111,444,648	15.885
16	114,116,326	15.556
17	116,550,889	15.251
18	118,948,342	14.990
19	121,201,122	14.754
20	124,031,812	14.622
21	126,199,539	14.442
22	128,208,122	14.273
23	130,140,113	14.120
24	132,150,697	13.999
25	133,968,343	13.877

7 Boiler Load Sensitivity Analysis

This section of the program performs a sensitivity analysis on the effect of varying boiler load on a particular installation considered in the CHPECON program. This particular function is implemented as an adjunct to the Sensitivity Analysis described earlier. This ability is provided by the specific program modules added to CHPECON discussed below. The boiler load sensitivity analysis will allow you to understand the results of changing boiler loads for an existing facility, which could occur, for example, if the base population varies or if the focus of the site is changed.

Functional Description of Implementation

The basic approach for implementing the Boiler Load Sensitivity Analysis section of the program is the following:

1. Determine the baseline average monthly steam flows for the site under study,

2. Vary the average monthly steam flows for the case under study, then run a complete cost model analysis to determine life cycle costs with the new average steam flows, and

3. Iterate step 2 for each of the user-supplied variation steps between the minimum and maximum values.

The minimum limit on average monthly steam flow (AMSF) that is acceptable is from 40 percent of the baseline values to 100 percent (no change). The maximum limit on AMSF that is acceptable is from 100 to 150 percent of the baseline. The step size variation for this is from 1 to 20 percent. The values generated are modified to include 100 percent as a reference. For example, if 50 percent is the minimum, 150 percent is the maximum, and 20 percent is the step size, the following values are used to modify the baseline AMSF: 50, 70, 90, 100, 110, 130, and 150 percent.

One file is created to contain the results of the sensitivity analysis. This is a permanent file that is given the same name as the screening model with an extension of "@LS". For example, a case that is stored in the file "QWERTY.DBF" and is listed

as "QWERTY" in the screening and cost model listings, will have a boiler load sensitivity analysis file named "QWERTY.@LS" that can be accessed by CHPECON for printing at a later time. Any boiler load sensitivity file created remains in the working directory after the analysis is completed, until you delete it.

The printing functions operate in a similar fashion to the other segments of CHPECON. When the option is selected, a list of files for that format are displayed. Once you highlight the files to be printed, the program continues with the printing.

User Interface

A series of menus guide you through the necessary questions to complete an analysis. The initial screen for CHPECON, as shown in Figure 54, reflects the option to access the boiler load sensitivity analysis.

```
        Central Heating Plant Economics Evaluation Program 08/01/92
                               Main Menu

1 -- Screening Models                    6 -- Update Databases

2 -- Cost Models                         7 -- System Utilities

3 -- Multiple Run Analysis

4 -- Sensitivity Analysis

5 -- Load Sensitivity Analysis           Q -- Quit (exit program)

Use ↑↓ to move highlight or enter first character to select option
------------------------------------------------ ---------------------------
Run boiler load sensitivity analysis
```

Figure 54. Initial menu screen for CHPECON.

After you select the boiler load sensitivity analysis option, the menu presented in Figure 55 is shown, allowing you to run any new plant sensitivity analysis or print existing reports. The Quit option returns you to the previous CHPECON main menu.

Central Heating Plant Economics Evaluation Program 08/01/92 Main menu -- load sensitivity
1 -- New plant 2 -- New plant with cogeneration 3 -- New plant with third-party cogeneration 4 -- New plant with consolidation P -- Print report Q -- Quit (return to main menu) Use ↑↓ to move highlight or enter first character to select option -- --------------------------- New boiler plant load sensitivity analysis for heating and process loads

Figure 55. Menu screen for boiler load sensitivity analysis.

After you select the desired base case from the list of available files, the system shows the screen in Figure 56. At this point, you are asked to enter the desired values for the minimum, maximum, and step size. The values must be accepted (by answering Yes to the question) before proceeding to the question about continuing the analysis. Answering No returns to the menu; answering Yes starts the analysis.

Minimum load fraction variation: 50 %
Maximum load fraction variation: 150 %
Load fraction step size: 10 %
Accept values? (Y/N) Y
Proceed with analysis? (Y/N) Y

Figure 56. Variation limits entry screen for boiler load.

Once started, the program displays the screen shown in Figure 57. As each life cycle cost is computed, the value is displayed on the screen. After completing the run, CHPECON waits for you to press a key, then returns to the menu.

Working on 150% load factor (50% -- 150%)

Change	Total Load, klb steam	Life Cycle Cost	LCS,$/1000lb steam
50%	407,040	118,416,751	23.396
60%	488,448	122,458,081	20.162
70%	569,856	126,499,412	17.852
80%	651,264	130,540,742	16.120
90%	732,672	134,582,073	14.772
100%	814,080	138,623,403	13.694
110%	895,488	142,664,734	12.812
120%	976,896	146,706,065	12.077
130%	1,058,304	150,747,395	11.455
140%	1,139,712	154,788,726	10.922
150%	1,221,120	158,830,056	10.460

Press any key to continue...

Figure 57. Boiler load sensitivity analysis cost report screen.

The reports that have been generated and stored can be accessed for printing through the Print report option of the multiple run analysis menu. Once selected, CHPECON displays the screen shown in Figure 58. Make a selection by moving the highlighting bar with the <Up> and <Down> keys to the desired file, and pressing the <+> key to mark it. Pressing the <-> key unmarks a file for printing. Marking more than one file allows you to print multiple files from one selection screen. Once the desired files are marked, pressing <Enter> will cause the program to print the report files. Printing can be output to either the printer or ASCII text files. If printed to an ASCII text file, the file name is the same as the analysis file, with the extension ".$LS". If no files are selected, you are asked to confirm that printing is not requested. The program either continues or returns to the menu based on the answer.

```
P --File-- Rpt Type Description
                    --- top of list ---
NP1      ‖ S ‖ NP ‖ joliet army ammunition plant ■ Dump Grate Spreader Stoke


↑↓ to move highlight
+/- to select/unselect report, <ENTER> to print
```

Figure 58. Boiler load sensitivity analysis report printing.

Review of Output

The output from the boiler load sensitivity analysis is contained in the report that the program generates. It is composed of three parts: the information about the site, the

baseline boiler loads (average monthly steam flows), and the variation and its effects. An example of the first section is shown in Table 16, and is similar to the site information of the other reports generated by CHPECON. The example uses Joliet Army Ammunition Plant weather data and arbitrarily selected AMSFs.

An example of the baseline boiler loads section of the report is shown in Table 17.

Table 16. Boiler load sensitivity analysis report—site information section.

Central Heating Plant Economics Evaluation -- Load Sensitivity Page 1
File: NP1 Type: New plant (NP)
Desc: joliet army ammunition plant
Tech: Dump Grate Spreader Stoker, w/ fly ash reinjection

Base Information

State: IL - Illinois
PMCR: 270,000 lb/hr steam
Base DOE Region: 2
Number of boilers: 4

Steam Properties: 150 psi (1195.6 Btu/lb)
Inlet water temp: 97 deg F enthalpy: 65.2 Btu/lb

Coalfield:
Coal code: W191056
desc: STRIP
State: IN - Indiana
Distance from base: 221 miles
Coal type: bituminous
(properties on a dry basis)
hhv: 13150 Btu/lb fixed carbon: 53.70% volatiles: 39.60%
ash: 6.70% sulfur: 1.50%
Coalfield DOE Region: 2

Table 17. Boiler load sensitivity analysis report—baseline boiler loads section.

Boiler Load Baseline Parameters

Average Monthly Steam Flows (million Btu/hr)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
200	170	140	110	55	40	40	35	50	75	90	115

The example of the load sensitivity analysis in Table 18 shows the information that resulted from the analysis. It consists of the annual steam flow delivered at the given boiler load factor, and the associated life cycle cost and levelized cost of service.

Table 18. Boiler load sensitivity analysis report -- load sensitivity analysis section.

Load Sensitivity Analysis

Boiler Load Variation

Change (percent)	Total Load, klb steam	LifeCycle Cost	LCS ($/1000lb steam)
50	407,040	118,416,751	23.396
60	488,448	122,458,081	20.162
70	569,856	126,499,412	17.852
80	651,264	130,540,742	16.120
90	732,672	134,582,073	14.772
100	814,080	1 38,623,403	13.694
110	895,488	142,664,734	12.812
120	976,896	146,706,065	12.077
130	1,058,304	150,747,395	11.455
140	1,139,712	154,788,726	10.922
150	1,221,120	158,830,056	10.460

Remember when evaluating the results of this analysis is that there is no determination as to whether the facility is capable of delivering above or below the design capacity to the extent the analysis can use. A detailed design analysis and more complete knowledge about the actual steam flow requirements is necessary for this.

8 Update Databases Operation

Selecting "Update Databases" from the main menu for CHPECON allows you to update information the program uses when determining the construction and operating characteristics of a coal-fired boiler facility. The menu listing of the different databases that can be modified is displayed in Figure 59. Select one of the databases to be updated by entering the number or letter associated with the database on the menu.

```
          Central Heating Plant Economics Evaluation Program          11/19/92
                              Main menu — update data

   1 -- Coal Field Information
   2 -- Acceptable Coal Properties Information
   3 -- Military Base Information
   4 -- Boiler Stack Emission Regulations
   5 -- Equipment Emission Factors
   6 -- Construction Productivity and Wage Information
   7 -- Operations Labor Staffing and Wage Information

   8 -- Copy INVENTORY site info to Military Base Info

   Q -- Quit (return to main menu)

 Use ↑ ↓ to move highlight or enter first character to select option

   Enter/modify names, locations, and properties of coalfields
```

Figure 59. Main menu of Update Databases option.

Update Databases Option 1: Coalfield Information

Selecting the option to update coalfield information allows you to update the characteristics of the coal from a particular coalfield, and to add information about new coalfields that can be considered for use in a coal-fired boiler.

Figure 60 shows the display for the coalfields' properties when this option is selected. All the information used by the CHPECON program for a particular coalfield is on one

screen. The display is divided into logical sections. The area within the box is coalfield information and the area below the box is for the menu prompts and message display. The information is accessed and updated through this menu. Enter the capitalized letter in the option description to select an option.

Coalfield location last changed: 09/01/88

State: TN - Tennessee   Location: ALLEN COAL CO
County: MARION   Lat: 34°59'59" Long: 85°33'31"

Proximate Analysis
Moisture: 2.90 % (as delivered)
(dry basis)——————————

Fixed Carbon: 69.20 %
Volatile: 28.30 %
Ash: 2.50 %

Ultimate Analysis -- (dry basis)
Carbon: 85.30 %
Nitrogen: 1.60 %
Sulfur: 0.80 %
Hydrogen: 5.30 %
Oxygen: 4.50 %

Miscellaneous
Gross Calorific Value (dry): 15280 Btu/lb
Rank: B
Hemispherical Temperature: 2435 °F
(H=½W, reducing)

Hardgrove Grindability Index: 0.0
Free Swelling Index: 9.0
Code Number: W193641
Note:

Edit field / Add field / move Forward / move Backward   Delete field / change Views / Print field list / Quit
Option (E/A/F/B/D/V/P/Q)   « »

Figure 60. Screen display for detailed view of coalfield information.

Edit field <E> permits editing the displayed coalfield.

Add field <A> adds a blank field entry, then goes to the editing subroutine to allow entering the correct values for a new coalfield.

Move Forward <F> displays the next coalfield (as if flipping forward through a card file, toward the end of the file) until the end is reached.

Move Backward <B> displays the previous coalfield (moving toward the beginning of the file) until the first entry is reached. The entries in the file are arranged by state.

Delete field <D> causes the field currently displayed to be eliminated from the file. The information that was entered is lost. As a check, the system asks you to confirm the decision to delete a coalfield.

Change Views <V> switches to a display containing less information about an individual field but allows many fields to be displayed at one time. This is discussed in detail below.

Print a field list <P> allows you to print entries from the coalfield database. Selecting this option brings up another prompt, asking if you want to print the displayed entry, the entries for a single state, all entries, or quit and return to the main screen without printing. If the displayed field or all fields is desired, the program begins printing. If state printing is requested, the system asks for the name or abbreviation of the state to be printed. After answering the prompt for the state, the program begins printing.

Quit <Q> returns you to the Update Data Main Menu.

Changing the view from the detailed display of the coalfield information brings up a display showing many coalfield entries per screen, but less information about each coal field. An example of the display is presented in Figure 61. The menu options are the same as for the detailed display; however, they work somewhat differently. Editing a field <E> requires you to first indicate which entry should be edited out of the list displayed. Use the up and down arrow keys on the cursor keypad to move the pointer to the entry you want to edit; then press "E." Adding <A> creates a blank entry that places information in the file. Moving Forward <F> and Backward <B> moves by screens of information. Since many coalfields are displayed, <F> and <B> allows quicker movement through the file. Deleting a field <D> requires you to first indicate which coalfield should be deleted. Deleting in this view also requires a confirmation, as did deleting in the detailed view. Changing Views <V> in this view moves the user back to the detailed view. Printing a field list <P> follows the same procedure as Quitting.

Coal Field Information Management Program 09/18/89

Condensed View of Coal Fields

State	Rank	County	Location
PA	B	ELK	STRIP MINE
PA	B	ELK	STRIP MINE
TN	B	MARION	ALLEN COAL CO
TN	B	GRUNDY	FOUR SEASONS COAL CO
TN	B	MARION	PETROLEUMS ENERGY SERV INC
TN	B	BLEDSOE	PIONEER COAL CO
TN	B	SEQUATCHIE	SOUTHERN ENERGY RES CO
TN	B	BLEDSOE	LUCKY CUMBERLAND COAL CO
TN	B	BLEDSOE	LAMB CREEK COAL CO
TN	B	BLEDSOE	SAUNDERS COAL CO
TN	L	LAUDERDALE	STATE PRISON FARM
TN	B	ANDERSON	JACKSON MINING CO
TN	B	MORGAN	G&B COAL CO

Edit field / Add field / move Forward / move Backward Delete field / change Views / Print field list / Quit

Option (E/A/F/B/D/V/P/Q) « »

Figure 61. Screen display for condensed view of coalfield information.

The information displayed in the detailed view is divided into logical sections within the box. The first section is the coalfield's location or description of the mine. This should be the actual name of the mine (preferred) or a description of the type of site. The last changed date is displayed, but is not changed by the user. When a field's data is edited, or when it is first added, the last changed date is automatically updated to the date stored as the current one in the computer system's clock. The latitude displayed is the north (assumed) latitude of the coal field in the format DDD°MM'SS", where DDD is in degrees, MM is in minutes, SS is in seconds. The longitude displayed is the west (assumed) longitude of the coal field in the format DDD°MM'SS", where DDD is in degrees, MM is in minutes, SS is in seconds.

The next boxed-in area of the detailed view contains the coal's proximate analysis. The moisture fraction of the coal is as delivered, in percent, from the proximate analysis laboratory results. The next three values are for the coal on a dry or moisture-free basis as noted on the screen. The percentage values are for the fraction of volatiles in the coal, the fraction of fixed carbon in the coal and the fraction of ash in the coal. The total of these three values must equal 100 percent. If the sum of the values does not equal 100 percent, a message on the right side of the screen is displayed. If you ignore, this message, the system will display another message when the data screen is completed informing you that you cannot proceed. This is different than the prompt that indicates whether the information entered should be accepted.

The next boxed-in area is for the ultimate analysis of the coal on a dry basis. The values are for the fractions of carbon, hydrogen, sulfur, oxygen, and nitrogen found in the coal. These five values and the ash value should total 100 percent. In the same manner as the proximate analysis, if the values entered do not equal 100 percent, a message is displayed on the right side of the screen. The system stops at the end of the entries with the longer message that the ultimate analysis values do not total to 100 percent. It is possible to have both the proximate and ultimate totals not be equal to 100 percent if an erroneous value was entered for ash.

The miscellaneous values describe the coal in more general terms. The gross calorific value (heating value on a dry or moisture free basis) is in Btu/lb of coal. The expected range is from 5,000 to 20,000 Btu/lb. The rank is the general type of coal. Acceptable values to the program are: B (bituminous), SB (sub-bituminous), L (lignite), A (anthracite), and SA (semi-anthracite). The program continues to prompt until one of these values is entered. The hemispherical temperature is the value defined by height that equals 0.5 width in a reducing environment, measured in degrees Fahrenheit. Acceptable values are from 1000 to 3500 °F. The Hardgrove Grindability Index has an acceptable value range from 20 to 120. The Free Swelling Index has an acceptable value range of from 0 to 10. The code number is a unique alphanumeric element given to the entry for later identification. The note area contains any additional information that should be recorded about the field. For example, the note might indicate the coalfield is the one used by a certain installation, or that the reserves of the coalfield are limited. Anything that may be useful in deciding to use a coalfield should be placed in the note space.

For some of the information about a coalfield, a value of 0 can be entered instead of a value in the expected range. This option has been provided for the times when some values are not yet known. However, the proximate analysis, gross calorific values, and the latitude and longitude must be entered. Table 19 summarizes the error checking in the program.

Table 19. Summary of error checking on entered data.

Information	Acceptable Values
State	Must be one of the 50 states.
Location entry	No error checking implemented. Can be blank.
County entry	No error checking implemented. Can be blank.
Latitude	The latitude must be in the format DDD°MM'SS", where DDD is in degrees, MM is in minutes, SS is in seconds. DDD must be in the range from 25° to 72°. MM and SS must be a value of 00 to 59, inclusive.

Table 19. Cont'd.

Longitude	The longitude must be in the format DDD°MM'SS", where DDD is in degrees, MM is in minutes, SS is in seconds. DDD must be in the range from 63° to 172°. MM and SS must be a value of 00 to 59, inclusive.
Moisture	Moisture fraction of the coal should be in the range of 0 to 60 percent, inclusive.
Fixed Carbon	Fraction of fixed carbon in the coal must be in the range of 20 to 99 percent, inclusive. Total of fixed carbon, volatiles, and ash must equal 100 percent.
Volatiles	Fraction of volatiles in the coal must be in the range of 0 to 60 percent, inclusive. Total of fixed carbon, volatiles, and ash must equal 100 percent.
Ash	Fraction of ash in the coal must be in the range of 0 to 50 percent, inclusive. Total of fixed carbon, volatiles, and ash must equal 100 percent.
Carbon	Fraction of carbon can have a value from 20 to 99 percent, inclusive. Total of carbon, hydrogen, sulfur, oxygen, nitrogen (ultimate analysis), and ash from proximate analysis must total to 100 percent.
Hydrogen	Fraction of hydrogen can have a value from 0 to 30 percent, inclusive. Total of carbon, hydrogen, sulfur, oxygen, nitrogen (ultimate analysis), and ash from proximate analysis must total to 100 percent.
Sulfur	Fraction of sulfur can have a value from 0 to 20 percent, inclusive. Total of carbon, hydrogen, sulfur, oxygen, nitrogen (ultimate analysis), and ash from proximate analysis must total to 100 percent.
Oxygen	Fraction of oxygen can have a value from 0 to 50 percent, inclusive. Total of carbon, hydrogen, sulfur, oxygen, nitrogen (ultimate analysis), and ash from proximate analysis must total to 100 percent.
Nitrogen	Fraction of nitrogen can have a value from 0 to 30 percent, inclusive. Total of carbon, hydrogen, sulfur, oxygen, nitrogen (ultimate analysis), and ash from proximate analysis must total to 100 percent.
Gross Calorific Value	Heating value must be in the range of 5,000 Btu/lb to 20,000 Btu/lb, inclusive.
Rank	The rank, or type, of the coal must be one of the following five values: B = bituminous SB = sub-bituminous L = lignite A = anthracite SA = semi-anthracite
Hemisphere Temperature	Hemispherical temperature of the coal (defined as height = Temperature 0.5 * width) is in the range of l000 to 3500 °F, inclusive, or 0 if no value is known.
Hardgrove Grindability Index	The index must be in the range of 20 to 120, inclusive, or 0 if no value is known.
Free Swelling Index	The index must be in the range of 0 to 9, inclusive, with 0 either a real value or representative of no value known.
Code Number	The code number must be a unique entry in the database. It cannot be a blank entry.
Note:	No error checking implemented. Can be a blank entry.

Update Databases Option 2: Acceptable Coal Properties

Different boiler technologies have varying tolerances to certain components of coal. It is through this premise that the parameters are defined for this program. These entries are used when the coalfield properties are searched for acceptable coalfields.

The main display for this option is shown in Figure 62. The properties are grouped by boiler technology, then ordered by coal type (anthracite, bituminous, lignite, sub-bituminous). The coal type is indicated by the left column with the first letter of each coal type. The minimum and maximum values for moisture are first displayed, followed by volatiles, fixed carbon, ash, and heating value. The value for free swelling index is only at its maximum; any coal at or below this value is acceptable. The opposite is true of the hemispherical temperature. Any coal that at least meets this minimum, in degrees F, is acceptable. The moisture, volatiles, fixed carbon, and ash are all presented on a percent basis, including moisture. The heating values are indicated as the highest heating values for the coal in Btu/lb, including moisture.

Acceptable Coal Properties 09/01/89

Moist Blr/Cl	Volatiles Lo/Hi	Fxd C Lo/Hi	--Ash-- Lo/Hi	Heating Val Lo/Hi	FrSwl Max	Hemi Min Temp
1 - Dump Grate Spreader Stoker, w/ fly ash reinjection						
Bituminous						
5.0/15.0	30.0/40.0	40.0/50.0	5.0/10.0	10500/14000	7.0	2300
Lignite						
25.0/45.0	30.0/45.0	40.0/55.0	5.0/10.0	6300/8300	7.0	2300
Subituminous						
15.0/30.0	30.0/40.0	30.0/50.0	5.0/10.0	8300/11500	7.0	2300
2 - Dump Grate Spreader Stoker, w/o fly ash reinjection						
Bituminous						
5.0/15.0	30.0/40.0	40.0/50.0	5.0/10.0	10500/14000	7.0	2300
Lignite						
25.0/45.0	30.0/45.0	40.0/55.0	5.0/10.0	6300/8300	7.0	2300
Subituminous						
15.0/30.0	30.0/40.0	30.0/50.0	5.0/10.0	8300/11500	7.0	2300
3 - Vibrating Grate Spreader Stoker, w/ fly ash reinjection						
Bituminous						
5.0/15.0	30.0/40.0	40.0/50.0	5.0/15.0	10500/14000	7.0	2300
Lignite						
25.0/45.0	30.0/45.0	40.0/55.0	5.0/15.0	6300/8300	7.0	2300
Subituminous						
15.0/20.0	30.0/40.0	40.0/50.0	5.0/15.0	8300/11500	7.0	2300

Forward / Backward / Edit / Print / Delete / Quit « »

Figure 62. Display screen for updating acceptable coal properties.

The options that are available once you have updated the emission factors are shown on the lowest line of the screen. The options are similar to the other database updating functions and are selected similarly, by typing the first letter of the command. Forward <F> advances the display through the increasing values of boiler technology, until the end of the data file is reached. Conversely, Backward <B> moves the display through decreasing boiler technology values until the beginning of the data file is reached. Print <P> prints a list of the entries stored in the database in the same format as the display. Delete <D> will remove any particular entry. You must enter the boiler technology and the coal type to define which entry to delete, then confirm your decision. Quit <Q> closes the database and returns you to the Update Database menu.

Edit <E> is used to change a value or add a new boiler/coal type. When editing, the screen changes to that shown in Figure 63 after the boiler technology and coal type are entered. Once these values are entered, you can Accept <A> the values just entered, Change <C> the values again, or Quit <Q> to abandon the entries that you just made. Accepting saves the entry by either modifying the old stored values or by adding a new record if needed. Quitting means that just this last displayed change is abandoned, not the previous set of changes. Once previous changes are accepted, they stay in memory until deleted or changed again.

Update Databases Option 3: Military Base Information

Selecting the option to update base information allows you to update weather and other information about military bases, and to add new bases to those available for study.

Figure 64 shows the display for the military base weather data program that appears when you select this option. The information used by CHPECON about a military base is contained on two screens that are divided into logical sections. The center section of the first screen displays information about the military base and winter design data. The area at the bottom is for the menu prompts and display of program messages. Information is accessed and updated through this menu. To select an option the capitalized letter in the option description is pressed.

Edit base <E> permits editing the displayed military base.

Add base <A> adds a new entry. This consists of two steps, adding a blank field entry, then going to the editing subroutine to enter the correct values for a new military base.

Acceptable Coal Properties 09/01/89						
Moist Blr/Cl	Volatiles Lo/Hi	Fxd C Lo/Hi	--Ash-- Lo/Hi	Heating Val Lo/Hi	FrSwl Max	Hemi Min Temp
3 - Vibrating Grate Spreader Stoker, w/ fly ash reinjection						
Bituminous						
5.0/15.0	30.0/40.0	40.0/50.0	5.0/15.0	10500/14000	7.0	2300
Lignite						
25.0/45.0	30.0/45.0	40.0/55.0	5.0/15.0	6300/8300	7.0	2300
Subituminous						
15.0/20.0	30.0/40.0	40.0/50.0	5.0/15.0	8300/11500	7.0	2300
4 - Vibrating Grate Spreader Stoker, w/o fly ash reinjection						
Bituminous						
5.0/15.0	30.0/40.0	40.0/50.0	5.0/15.0	10500/14000	7.0	2300
Lignite						
25.0/45.0	30.0/45.0	40.0/55.0	5.0/15.0	6300/8300	7.0	2300
Subituminous						
15.0/20.0	30.0/40.0	40.0/50.0	5.0/15.0	8300/11500	7.0	2300
5 - Reciprocating Grate Spreader Stoker, w/ fly ash reinjection						
Bituminous						
5.0/15.0	30.0/40.0	40.0/50.0	5.0/15.0	10500/14000	7.0	2300
Lignite						
25.0/45.0	30.0/45.0	40.0/55.0	5.0/15.0	6300/8300	7.0	2300
Subituminous						
15.0/20.0	30.0/40.0	40.0/50.0	5.0/15.0	8300/11500	7.0	2300

Moisture	Volatiles	Fxd Carbon	-- Ash --	Heating Val	Hrdgrv Grnd
Low: 5.0	Low: 30.0	Low: 40.0	Low: 5.0	Low: 10500	Low: 0.0
High: 15.0	High: 40.0	High: 50.0	High: 15.0	High: 14000	High: 0.0

High Free Swell: 7.0   Hemi Temp, °F: 2300   Last Chg 09/01/89

Accept / Change / Quit (without saving) « »

Figure 63. Acceptable coal properties display with prompts for new factors.

move Forward <F> displays the next military base (as if flipping through a card file) until the end is reached.

move Backward <B> displays the previous military base (moving toward the beginning of the file) until the first entry is reached. The entries in the file are arranged by state.

```
Military Base Information Management Program     09/18/89
                    Military base update
---------------------------------------------------------
State: MO - Missouri     Last changed: 09/01/88
Latitude:  37°45'  Longitude:  92°9'  ID code: MO-1
County:
Base name: Fort Leonard Wood
Base in a non-attainment area: N
Comment:
Annual heating degree days:  4707
Winter heating design temperature (97.5%):   9°F
-----------------------------------------------------------

Edit base / Add base / move Forward / move Backward / Delete base
change Views / Switch to weather page / Print base list / Quit

              Option (E/A/F/B/D/V/S/P/Q)     « »
```

Figure 64. Screen display for detailed view of military base information.

Delete base <D> causes the field currently displayed to be eliminated from the file. The information is lost. As a check, the system asks you to confirm the decision to delete a military base.

Change Views <V> switches to a display that holds less information about an individual base but allows many bases to be displayed at one time. This is discussed in detail below.

Switch to weather page <S> switches the display to the second page (screen) to show the detailed weather data (annual and monthly average outdoor temperatures and monthly heating degree days), as shown in Figure 65. Pressing <S> again switches back to the first screen. Executing any other option also switches back to the first screen.

```
Military Base Information Management Program     09/18/89
                    Military base update
---------------------------------------------------------
          Base name: Fort Leonard Wood
          Annual average outdoor temperature:  55°F

     MHDD   Tam            MHDD   Tam            MHDD   Tam
Jan  1002   32°F      May   130   65°F      Sep    85   68°F
Feb   856   34°F      Jun    29   73°F      Oct   298   57°F
Mar   616   44°F      Jul    10   77°F      Nov   555   46°F
Apr   267   58°F      Aug    20   74°F      Dec   839   37°F
-----------------------------------------------------------
Edit base / Add base / move Forward / move Backward / Delete base
change Views / Switch to weather page / Print base list / Quit
     Option (E/A/F/B/D/V/S/P/Q)     « »
```

Figure 65. Screen display for detailed view of military base weather information.

Print base list <P> allows you to print entries from the coalfield database. Selecting this option brings up another prompt, asking if you want to print the displayed entry, the entries for a single state, all entries, or quit and return to the main screen without printing. If the displayed field or all fields is desired, the program begins printing. If printing by state is requested, the system asks for the name or abbreviation of the state to be printed. After answering the prompt for the state, the program begins printing.

Quit <Q> returns to the previous menu if the program was run as part of the overall program set. Quit will return to the operating system if the program was run as a separate module.

Changing the view from the detailed information display brings a display showing many military base entries per screen, but less information about each military base. An example of the display is presented in Figure 66. The menu options are the same as for the detailed display; however, they work somewhat differently. Edit base <E> requires you to first indicate which entry should be edited out of the list displayed, then proceeds as before. Use the up and down arrow keys on the cursor keypad to highlight an entry, then press "E." Add base <A> creates a blank entry, then switches to editing the blank entry to place information in the file. Moving Forward <F> and Backward <B> moves up or down one screen at a time; since there are many military bases displayed, this allows quicker movement through the file. Delete field <D> requires you to first indicate which entry should be deleted, as for the editing option. Deleting in this view also requires a confirmation, as did deleting in the detailed view. Switch to weather page <S> causes an automatic switch to the detailed view in addition to the display of the weather data. Change Views <V> in this view moves back to the detailed view. Print base list <P> is the same as before, as is Quit <Q>.

If you select the editing (or adding) option from the main menu, the detailed view is switched back if needed, and the system presents the first screen of information. This is indicated by the legend "Page 1" in the upper-left corner of the screen (Figure 67). The information displayed in the detailed view is divided into sections. The first section is the military base's location, and includes the state and county (borough, province, etc.). The last changed date shown on the general display is absent when editing information because you cannot directly change it. When a base's data is edited, or first added, the last changed date is automatically updated to the current date stored in the computer system's clock. The latitude displayed is the north (assumed) latitude of the military base in the format DDD° MM', where DDD is in degrees, MM is in minutes. Acceptable values for latitude are between 25° and 72°. The longitude displayed is the west (assumed) longitude of the military base in the format DDD° MM', again where DDD is in degrees, MM is in minutes. Acceptable values for longitude are between 63° and 172°.

```
Military Base Information Management Program    09/18/89
                    Military base update
State    Base
 MN      Twin Cities Ordnance Plant
 MN      Camp Ripley, Little Falls
 MO      Fort Leonard Wood
 MO      St. Louis Army Ammunition Plant
 MO      Gateway Army Ammunition Plant, St. Louis
 MO      Lake City Army Ammunition Plant
 MS      Mississippi Army Ammunition Plant
 MS      Camp Shelby, Hattiesburg
 MT      Fort Missoula, Missoula
 NC      Fort Bragg
 NC      Camp Mackall
 NC      Sunny Point Military Ocean Terminal
 NC      Tarheel Army Missile Plant, Burlington
------------------------------------------------------
Edit base / Add base / move Forward / move Backward / Delete base
change Views / Switch to weather page /Print base list/ Quit
     Option (E/A/F/B/D/V/S/P/Q)    « »
```

Figure 66. Screen display of condensed view of military base information.

```
Military Base Information Management Program    09/18/89
                    Military base update
Page 1

          State: MO - Missouri          Latitude: 37° 45'   Longitude: 92° 9'
          ID code: MO-1                 County:
          Base name: Fort Leonard Wood

 Base in a non-attainment area: N

 Comment:
          Annual heating degree days:  4707
          Winter heating design temperature (97.5%):  9°F

    Accept (save) / Change / Quit (without saving)
    Option (A/C/Q)    « »
```

Figure 67. Editing display of military base information, page 1.

The ID code is a unique alphanumeric label you give to the entry. If more than one base is given the same name, the ID code helps to identify which set of information was used. The program checks existing entries to ensure the entry is unique, and not blank.

The base name is the entry used as the heading for all reports produced by CHPECON. It can be a real base name, a fictitious entry, or any other note that is useful for identifying the evaluation.

The nonattainment area entry represents a region that is not in compliance with ambient air quality regulations. This situation may make it considerably more difficult to obtain the necessary permits for a coal-fired boiler plant.

The annual heating degree days are the mean annual number of degree days using a base of 65 °F and a 30-year normal period of record, when available. The acceptable range for annual heating degree days is from 0 to 20,000. The winter heating design temperature is dry bulb temperature (°F) that is equalled or exceeded 97.5 percent of the time, on the average, during the coldest three consecutive months. For the contiguous United States, these months have been standardized as December, January, and February, even though at a few sites March was colder than December. Acceptable values for the winter heating design temperature are from -50 to 80 °F.

After you complete this information, the program asks if you want to accept the data, change it again, or quit and not save the data. Changing allows you to go through the screen entries again. Quitting returns you to the information display without changing the stored values. Accepting allows you to proceed to page 2 of the information, shown in Figure 68.

Military Base Information Management Program 09/18/89
Military base update

Page 2

Annual average outdoor temperature: 55°F

	MHDD	Tam		MHDD	Tam		MHDD	Tam
Jan	1002	32°F	May	130	65°F	Sep	85	68°F
Feb	856	34°F	Jun	29	73°F	Oct	298	57°F
Mar	616	44°F	Jul	10	7°F	Nov	555	46°F
Apr	267	58°F	Aug	20	4°F	Dec	839	37°F

Accept (save) / Change / Quit (without saving)
Option (A/C/Q) « »

Figure 68. Editing display of military base information, page 2.

The second information page is indicated by the "Page 2" legend in the upper-left corner. The program expects the entries to be numeric; values calculated from the temperature bin entries in the Engineering Weather Data manual. Annual average outdoor temperature is the first entry, with acceptable values from -50 to 80 °F. The program then asks for the monthly heating degree days (MHDD) for each of the

12 months. Acceptable values for monthly heating degree days are between 0 and 2500. It then asks for the average monthly outdoor temperature (Tam, or Temperature, ambient, mean) for each month, with acceptable values from -50 to 120 °F. After these values have been entered, the program presents the options to Accept (save) / Change / Quit (without saving). This question applies only to this page of information. (The first page was accepted to get to this level.)

Update Databases Option 4: Boiler Stack Emission Regulations

Selecting option 4 allows you to update emission regulation entries and to add new entries to the database. The entries in this file are used to establish the emission requirements for the military base's locale.

Figure 69 presents the display of the coal-fired boiler emission regulations when this option is selected. Only one emission type is displayed at a time. The screen is divided into two sections. The area within the box is emission information and the area below the box is for the menu prompts. The information is accessed and updated through this menu. To select an option, enter the capitalized letter of the option description.

Emission Regulation Update

State: KY - Kentucky
Region: 6 County lass IVA

Emission type: S - SOx (sulfur oxides)

Itm	Last Chg	Low	High	Value
1	09/01/88	0.00	10.00	8 * input (lb/hr)
2	09/01/88	10.00	250.00	10.8875 * input - 0.1338 (lb/hr)
3	09/01/88	250.00	1500.00	5.2 * input (lb/hr)
4	09/01/88	1500.00	21000.00	3.5 * input (lb/hr)
5	09/01/88	21000.00	99999.00	3.1 * input (lb/hr)

Edit item / Delete item / Forward / Backward / goto State / emission Type Region edit / Print item list / Quit
Option (E/D/F/B/S/T/R/P/Q) « »

Figure 69. Display of coalfield boiler emissions regulations.

The options on the main menu are:

Edit item <E> allows editing or adding emission regulation information, and is linked to the item number on the left side of the screen. This option is described in detail below.

Forward <F> moves through the information file to display the next type of emission standards for a given state or region. If there are none, it moves to the next region for the state, or to the next state. Movement through the file stops when the end of the information is reached.

Delete item <D> allows you to delete a particular item in the list displayed on the page. Once the deletion is confirmed, the remaining values are redisplayed with new item numbers.

Backward <B> moves to the logically previous set of emission standards; either the previous emission type, region, or state. Movement stops when the beginning of the information is reached.

goto State <S> upon choosing State, the cursor appears at the current screen's state. To change the state, insert the two letter abbreviation of that state. Because some states are further divided into regions, which might have more stringent rules, the program also prompts you to enter the appropriate region. Choose "0" to determine the emissions that apply to the entire state or enter "?" to display the list of regions. States can have emission regulations that apply to the entire state, limited regions of the state, or both. In trying to determine the emission regulations for an area within the state, check both the entire state and any pertinent regions. If the list of regions is long, the "?" in the menu prompt changes to "M", indicating "more." Pressing M will list the rest of the regions. To return to the main menu, enter a region number or 0 for the entire state. Any Federal regulations are viewed and updated under the special case of "US" as state. Federal regulations do not have regions.

emission Type <T> allows you to enter the type of emissions to review; *P* (Particulates), *N* (Nox), or *S* (SO_x). The screen will display the emission regulations for that pollutant in the presently displayed state or region. The information includes the coal type, low and high range of the boiler size (million-Btu/hr), and the equation defining the upper limit of the pollutant for that regulation.

Region edit <R> switches the display to that shown in Figure 70 and allows you to add or delete regions or edit the descriptions for the currently selected state. To edit another state's region list, you must first select the state. The options presented function in the same manner as the main menu's.

Edit permits selecting one region by highlighting, then editing the description shown.

Region	Description
1	Mariposa County APCD
2	Tuolumne County APCD
3	Northern Sierra AQMD
4	Tulare County APCD
5	North Coast Air Basin
6	Madera County APCD
7	Kern County APCD - Valley Basin
8	Kern County APCD - Desert Basin
9	County of Siskiyou APCD
10	Modoc County APCD
11	Imperial County APCD
12	Placer County APCD
13	Sutter County APCD
14	Shasta County AQMD
15	Tehama County APCD
16	Calaveras County APCD
17	Colusa County APCD
18	Great Basin Unified APCD

Edit / Add / Delete / Forward / Backward / Print / Quit
Option (E/A/D/F/B/P/Q) « »

Figure 70. Example of region edit screen.

Add creates a blank entry, and requests a region number, then allows entry of the description.

Delete permits deleting a region by highlighting it. The program asks you to confirm the deletion. If yes, the program displays the number of emission regulation entries that would also be deleted with the region, then asks you to confirm the deletion again.

Forward and **Backward** moves the display through the region list by screens, if there are more regions than can be displayed on one screen.

Print displays another menu, as shown in Figure 71, and allows printing a list of the regions either for the current State (that which is displayed), or for all states.

Quit returns you to the main menu.

Region	Description
1	Mariposa County APCD
2	Tuolumne County APCD
3	Northern Sierra AQMD
4	Tulare County APCD
5	North Coast Air Basin
6	Madera County APCD
7	Kern County APCD - Valley Basin
8	Kern County APCD - Desert Basin
9	County of Siskiyou APCD
10	Modoc County APCD
11	Imperial County APCD
12	Placer County APCD
13	Sutter County APCD
14	Shasta County AQMD
15	Tehama County APCD
16	Calaveras County APCD
17	Colusa County APCD
18	Great Basin Unified APCD

print regions for current State, regions for All states, or Quit
Option (S/A/Q) « »

Figure 71. Example of region print screen.

Print item list <P> allows you to print lists of emission regulations. When this option is selected, you are presented with another menu asking whether to print items that are Displayed, items for one State, All items, or Quit. This is shown in Figure 72. The print option is selected by pressing the appropriate capital letter. Quitting returns you to the main menu. Print items that are displayed prints only those items on the screen currently—one state, one region, one emission type. Printing items for one state prints the list for the state (which you need to specify) for all regions and for all emission types. Printing all prints a continuous list from beginning to end of the emission regulation data.

Quit <Q> this option returns you to the Update Data Main Menu.

Edit the displayed emission data by choosing Edit <E> on the main menu. After choosing this option, you need to enter the item number to edit or [+] to add a new item. Figure 73 shows the edit screen. The program asks you to input the low and high range of plant/boiler input applicability for the particular emission regulation. Many regulations have different allowable levels of emissions based on the size of the plant, with this range for defining that size.

Emission Regulation Update

State: CO - Colorado

Region: 0

Emission type: S - SOx (sulfur oxides)

Itm	Last Chg	Low	High	Value
1 A	09/01/88	0.00	250.00	1.2 * input (lb/hr)
2 A	09/01/88	0.00	250.00	90 % reduction
3 B	09/01/88	250.00	99999.00	0.4 * input (lb/hr)
4 B	09/01/88	250.00	99999.00	70 % reduction

Print items that are Displayed, items for one State, All items, or Quit (cancel print) -- Option (D / S / A / Q)
« »

Figure 72. Example of emission print screen.

Input range of application - Low: 10.00 High: 250.00

Last change in MMBtu/hr (enter 0 & 99999.99 for lower and upper limits) 09/01/88

Group identifier:
(to be used when more than one item is applicable for a given range)

Coal type covered:
[A] - anthracite [L] - lignite [ ] - all
[B] - bituminous [S] - sub-bituminous

Line type for emissions: 3 Value
1 - constant (lb/MMBtu) V1: 10.8875
2 - line (lb/MMBtu) V2: -0.1338
3 - power (lb/MMBtu)
4 - wt % coal
5 - % reduction
6 - ppm exhaust Function:
7 - % exhaust emis= {V1} * input ^ {V2}
8 - grains / SCF
9 - lb/million Btu
10 - lb/hr

Accept and save / Change values / Quit without saving
option:

Figure 73. Example of emission edit screen.

The group identifier is used when multiple equations apply to a range. This type of definition is prevalent in SO_x regulations. For example, it is usually used to indicate that both the values of 1.2 lb/MMBtu/hr and 90 percent reduction are applied to a particular boiler. When multiple definitions occur, the same group letter would be

used to identify the link between the definitions. If only one equation applies to a range, a group identifier is not used.

Coal type refers to the type of coal with which the regulation is concerned. Usually this entry is blank, indicating that it is applicable to all coals. However, if a differentiation between coal types is made, the types have to be entered as separate values. For example, if anthracite has one value and all others have another, entries have to be made with anthracite having one value, and bituminous, sub-bituminous, and lignite having the other value. Using this example, "anthracite and all" can be used if the anthracite value is lower than the "all" value, since the program searches out the strictest applicable regulations to meet. It will find the "all" value and the anthracite value and pick the anthracite for checking. On the other hand, if the anthracite value is higher than the "all" value, items must be defined for each coal type, because the program will incorrectly use the lower "all" value.

The equation type for emissions, and emission limit factors are the next values the program asks for. The number of limit factor values requested is determined by the equation type. Ten equation forms were developed based on the different representations used by the regulating agencies. An example of each of these is shown in Table 20. Table 21 explains each equation type in detail.

You can Accept and save the displayed values, Change the values (re-enter), or Quit without saving the entered values (return to the main menu without changing the information file).

Table 20. Example of equation types used to specify emission standards calculations.

Equation Type 1	State: AL -- Alabama Emission type: particulates Applicability input range: 1.00 MMBtu/hr to 10.00 MBtu/hr Group ID: Type of coal: -- all -- emissions [lb/hr] = 0.5 * input [10^6 Btu/hr]
Equation Type 2	State: NY -- New York Emission type: particulates Applicability input range: 10.00 MMBtu/hr to 250.00 MBtu/hr Group ID: Type of coal: -- all -- emissions [lb/hr] = 0.6 @ low -- 0.31 @ high
Equation Type 3	State: IL -- Illinois Emission type: particulates Applicability input range: 10.00 MMBtu/hr to 500.00 MBtu/hr Group ID: A Type of coal: -- all -- emissions [lb/hr] = 1.2 * input -0.23 [10^6 Btu/hr]
Equation Type 4	State: CT -- Connecticut Emission type: SO_x Applicability input range: 0.00 MMBtu/hr to 99999.00 MBtu/hr Group ID: A Type of coal: -- all -- allowed input = 1 % wt coal
Equation Type 5	State: CO -- Colorado Emission type: NO_x Applicability input range: 250.00 MMBtu/hr to 99999.00 MBtu/hr Group ID: A Type of coal: -- all -- reduction = 65 %

Table 20. Cont'd.

Equation Type 6	State: AK -- Alaska Emission type: SO_x Applicability input range: 0.00 MMBtu/hr to 99999.99 MBtu/hr Group ID: Type of coal: -- all -- emissions = 500 ppm in exhaust ==
Equation Type 7	State: MI -- Michigan Emission type: particulates Applicability input range: 0.00 MMBtu/hr to 99999.99 MBtu/hr Group ID: Type of coal: -- all -- emissions = 0.01 % in exhaust ==
Equation Type 8	State: AK -- Alaska Emission type: particulates Applicability input range: 0.00 MMBtu/hr to 99999.99 MBtu/hr Group ID: Type of coal: -- all -- emissions = 0.1 grains / SCF exhaust ==
Equation Type 9	State: WI -- Wisconsin Emission type: SO_x Applicability input range: 0.00 MMBtu/hr to 99999.99 MBtu/hr Group ID: Type of coal: -- all -- emissions = 1.1 lb/million Btu input ==
Equation Type 10	State: CA -- California Emission type: particulates Applicability input range: 0.00 MMBtu/hr to 99999.99 MBtu/hr Group ID: A Type of coal: -- all -- emissions = 10 lb/hr

Table 21. Description of equation types used for emission regulations.

Equation Type	Description of Equation
1	This type expresses the maximum allowable emissions (lb/hr) by multiplying a state regulation constant factor times the MMBtu/hr heat input. In the case Alabama, the 0.5 factor is to be multiplied by the heat input in MMBtu/hr.
2	This type gives the maximum allowable emissions (lb/hr) for a high and low heat input. For cases in between, a line of MMBtu/hr heat input vs. allowable emissions (lb/hr) should be used to determine the allowable emissions.
3	This type is expressed as a constant times the heat input (MMBtu/ hr) raised to a power. For example, for Illinois, 1.2 is to be multiplied by the heat input in MMBtu/hr raised to -0.23.
4	This type limits the weight percent of sulfur in the coal feed.
5	This type is the percent reduction input vs. output required of the pollutant.
6	This type expresses the allowable output in ppm.
7	This type expresses the allowable output in volume percent exhaust.
8	This type expresses the allowable output in grains/SCF exhaust.
9	This type limits the input of a pollutant material to a specified maximum value per MMBtu input.
10	This type expresses the allowable output in lb/hr.

Update Databases Option 5: Equipment Emission Factors

This option allows you to adjust the factors used to determine the emissions based on coal type and boiler technology.

If a particular technology is incompatible with a coal type, there should be no entry. However, there must be an entry for the acceptable technologies for the program to operate properly.

An example of the display when this option is selected is shown on Figure 74. The upper portion of the screen shows some of the entries already stored in the database. The entries are grouped by boiler technology, and then ordered by coal type, including anthracite, bituminous, lignite, and sub-bituminous. The date on the left side is when that entry was entered or last changed. The three values on the right side are the emission factors for each emission type.

	Equipment Emission Factors		09/01/89	
Technology	Coal Type	Nox	Sox	Particulates
1 - Dump Grate Spreader Stoker, w/ fly ash reinjection				
09/01/88	bituminous 15.0	38.0	20.0	
09/01/88	lignite	6.0	30.0	7.0
09/01/88	sub-bituminous	15.0	38.0	20.0
2 - Dump Grate Spreader Stoker, w/o fly ash reinjection				
09/01/88	bituminous 15.0	38.0	13.0	
09/01/88	lignite	6.0	30.0	7.0
09/01/88	sub-bituminous	15.0	38.0	13.0
3 - Vibrating Grate Spreader Stoker, w/ fly ash reinjection				
09/01/88	bituminous 15.0	38.0	20.0	
09/01/88	lignite	6.0	30.0	7.0
09/01/88	sub-bituminous	15.0	38.0	0.0
Forward / Backward / Edit / Print / Delete / Quit « »				

Figure 74. Display screen for updating equipment emission factors.

The available options are shown on the lowest line of the screen. The options are similar to the other database updating functions and are selected similarly—by typing the first letter of the command. Forward <F> and Backward <B> advances move the display through boiler technology values. Print <P> prints a list of the entries stored in the database in the same format as the display. Delete <D> will delete a particular entry. You must enter the boiler technology and the coal type to define which entry

to delete, then confirm your choice. Quit <Q> closes the database and returns the user to the Update Database menu.

Use the Edit option to add or change an entry. When you select Edit, the program asks for the boiler technology and coal type. The screen changes to allow you to update the factors, as shown in Figure 75. If you are adding an entry, the initial values for the three emission factors are 0. Otherwise, the values displayed are those in the database. After accepting the values by pressing <ENTER> or modifying them by typing in new values, you can tell the program to accept the entered values, allow another chance to change the values, or quit this step without modifying the database. Accepting saves the entry by either modifying the old stored values or by adding a new record if needed. Quitting means that just this last displayed change is abandoned (the previous set of changes, once accepted, remain in memory until deleted or changed again).

Equipment Emission Factors 09/01/89

Technology	Coal Type	Nox	Sox	Particulates
3 - Vibrating Grate Spreader Stoker, w/ fly ash reinjection				
09/01/88	bituminous	15.0	38.0	20.0
09/01/88	lignite	6.0	30.0	7.0
09/01/88	sub-bituminous	15.0	38.0	20.0
4 - Vibrating Grate Spreader Stoker, w/o fly ash reinjection				
09/01/88	bituminous	15.0	38.0	13.0
09/01/88	lignite	6.0	30.0	7.0
09/01/88	sub-bituminous	15.0	38.0	13.0
5 - Reciprocating Grate Spreader Stoker, w/ fly ash reinjection				
09/01/88	bituminous	15.0	38.0	20.0
09/01/88	lignite	6.0	30.0	7.0
09/01/88	sub-bituminous	15.0	38.0	20.0

Technology: 3 - Vibrating Grate Spreader Stoker, w/ fly ash reinjection

Type of coal: Bituminous

NOx: 15.0 SOx: 38.0 Part: 20.0

Accept / Change / Quit (without saving) « »

Figure 75. Equipment emission factors display with prompts for new factors.

Update Databases Option 6: Construction Productivity and Wage Information

This option permits modification of the construction labor rates that are used by the cost model routines in determining installation labor costs. Within this option you can edit the hourly rates and productivity factors, and print the list for a permanent record. The two options are displayed as another menu, as shown in Figure 76.

Coal Fired Boiler Plant Evaluation Model 09/01/89

Productivity and wage update

1 -- Update productivity and wages for states

2 -- Print listing of productivity and wages

Q -- Return to database update menu

Option (1/2/Q) « »

Figure 76. Construction productivity and wage information update menu.

Update Productivity and Wages for States

Each state has an hourly wage rate and a productivity factor. (See Volume 1 of this report for more information on these factors.) When you select the update option, the display lists the states in alphabetical order. You can then enter any changes to the database. The list is shown on three separate screens. Pressing <Enter> moves the cursor to the next field for entry. Pressing the <Up> arrow key moves the cursor back one state. If the cursor is on the first state on the screen and the second or third screens are displayed, pressing the <Up> arrow key moves the cursor to the last state on the previous screen.

Once all entries are made, the program asks whether to Accept, Change, or Quit. Accept new values will replace the previous values with the recently entered data. Change again starts at the beginning to further modify the changed values. Quit (abandon changes) will retain the entries before this option was selected. The update screen format with the final prompt on what to do with the new values (screen 3) is shown in Figure 77.

Prod	Wage	State	Prod	Wage	State
1.00	4.45	:South Carolina	1.00	12.00	:Wyoming
1.00	6.00	:South Dakota	1.00	10.00	:Tennessee
1.00	9.50	:Texas	1.00	14.41	:Utah
0.87	4.61	:Virginia	0.87	4.70	Vermont
1.00	8.00	:Washington	1.00	6.00	:Wisconsin
0.93	6.97	:West Virginia			

Accept new values / Change again / Quit (abandon changes)
(A/C/Q) « »

<ENTER> to accept data, ↑ to move up one entry

Figure 77. Last screen of the construction labor updating option, with final disposition prompt.

Print Listing of Productivity and Wages

Selecting the option to print a list of the productivity factors and hourly rates causes the program to immediately run the printing routine. It produces a dated list containing the productivity and wage rate for each of the 50 states and the District of Columbia. As a sample of the printout, the initial entries for this database are shown in Table 22.

Table 22. Example of productivity and wage listing with initial values.

Listing of productivity and wage update -- 09/01/89 -- page 1

Productivity	Wage	State
------------	------	-------
0.87	27.00	Alaska
1.00	13.00	Alabama
1.00	8.00	Arkansas
1.00	17.85	Arizona
1.00	23.00	California
1.00	12.00	Colorado
0.98	18.22	Connecticut
0.00	0.00	District of Columbia
1.00	18.05	Delaware
1.00	10.00	Florida
1.00	10.00	Georgia
1.00	20.00	Hawaii
1.00	14.77	Iowa
1.00	17.63	Idaho
1.21	18.05	Illinois
0.98	18.17	Indiana
1.00	11.55	Kansas
1.13	10.00	Kentucky
1.00	11.97	Louisiana
0.87	18.09	Massachusetts
1.00	12.94	Maryland
0.87	14.35	Maine
1.00	16.00	Michigan
1.00	17.50	Minnesota
1.00	18.00	Missouri
1.00	9.00	Mississippi
1.00	14.51	Montana
1.00	6.75	North Carolina
1.00	9.95	North Dakota
1.00	12.91	Nebraska
0.87	16.00	New Hampshire

Table 22. Cont'd.

	0.97	18.44	New Jersey
	1.00	11.30	New Mexico
	1.00	19.59	Nevada
	1.00	18.50	New York
	1.00	18.60	Ohio
	1.00	9.81	Oklahoma
	1.00	18.31	Oregon
	0.98	17.08	Pennsylvania
	0.87	19.07	Rhode Island
	1.00	4.45	South Carolina
	1.00	6.00	South Dakota
	1.00	10.00	Tennessee
	1.00	9.50	Texas
	1.00	14.41	Utah
	0.87	14.61	Virginia
	0.87	14.70	Vermont
	1.00	18.00	Washington
	1.00	16.00	Wisconsin
	0.93	16.97	West Virginia
	1.00	12.00	Wyoming

Update Databases Option 7: Operations Labor Staffing and Wage Information

Operating And Maintenance Staffing Levels

Staffing levels have been identified as an important element in the overall operating and maintenance cost of central heating plants. Staffing levels also provide insight into the operating characteristics and scheduling requirements that impact central heating plants.

To develop a more complete and realistic view of central heating plant (CHP) operations, the Institute of Gas Technology (IGT) had conducted an extensive survey of public and private CHPs. The goal of the survey was to provide comparative information for evaluating current procedures at DOD central heating plants; this information is useful in assessing the relative operational status and efficiency of DOD central energy plants. The survey contained a section relating to staffing levels at central heating plants. In addition, central heating plant expenses for operation and maintenance were also acquired. The IGT survey was targeted at four types of facilities: state universities, state and Federal prison complexes, hospitals, and private commercial and industrial facilities. Facilities surveyed included coal and oil/natural gas plants, with facility size ranging from 5000 lb/hr to 1,000,000 lb/hr. The listing of all labor categories, divided into operating and maintenance sections, is shown in Table 23. The number of personnel assigned to each category varies according to the type of fuel (coal, oil/gas, or coal slurry), the number of boilers selected, the size of the facility, and the presence of any electric cogeneration equipment. The duties of these personnel labor categories were reviewed in light of the plant staffing profile generated by the IGT survey to provide insight into the importance of various labor categories at non-DOD central heating plants.

Table 23. Facility staffing categories for central heating plants.

Operations:	
Plant Manager	Plant Engineer
Plant Technician	Plant Clerk
Plant Secretary	Plant Janitor
Shift Supervisor	Operator
Asst. Operator	Laborer
Fuel Equipment Operator	Asst. Fuel Equipment Operator
Fuel Equipment Laborer	
Maintenance:	
Maintenance Supervisor	Maintenance Mechanic
Electrical Maintenance	Maintenance Laborer

The survey revealed some very interesting information. The most relevant conclusion was that private facilities use considerably fewer operating personnel than public facilities. This was evident from the relative dollar amounts spent on operating and maintenance labor by private and public facilities. Total annual operating labor expenses were twice as great at public facilities than at private facilities, while maintenance labor expenses were twice as great at private facilities than at public facilities. The impact of these differences was apparent when considering factors such as average cost of steam, maintenance/replacement parts, and the need for outside contractor maintenance. The significantly lower costs in these categories at private facilities leads to the conclusion that superior maintenance procedures are responsible for reducing overall facility operating costs. Thus, the relative use of operating and maintenance personnel in a central heating plant can have a significant effect on overall life cycle costs.

Another conclusion from the IGT survey was that predictive and preventative maintenance programs appear to be effective in holding down the total cost of facility operation. The high degree of correlation between a large investment in maintenance labor and low operating costs, as well as the high correlation between high maintenance labor, and low maintenance and replacement costs, support this conclusion. This can be further extended by stating that a higher investment in maintenance can produce lower total steam costs.

Plant Staffing Revisions

In the CHPECON program, it is possible to allocate the equivalent of fractional workers to various labor categories. This is a recognition that these workers will devote a portion of their time to non-CHP duties. In addition, the program recognizes that certain labor categories need only be staffed during daytime hours, because

24-hour staffing is not required for some central heating plant functions. An example of this would be the fuel equipment laborer, who could perform the assigned duties during a normal daytime shift without the need for alternate shift staffing. The program also considers the effect that the number and size of boilers have upon determining staffing levels. For example, maintenance mechanic staffing levels can be revised based on the number and size of boilers. Correspondingly, the number of management personnel can be allocated in closer relation to the number of subordinate personnel. For example, shift supervisors and maintenance supervisors may be allocated according to the number of operators and maintenance mechanics, respectively, that are used (which depends on the plant size). The program also includes additional maintenance personnel whenever cogeneration equipment is present. Plant staffing changes to the program had a less dramatic effect on oil/natural gas plants, because these facilities require smaller staffs. Oil/natural gas plants do not require fuel handling personnel, and have reduced maintenance and operating requirements. Coal slurry plants represent a middle ground, due to their similarities to oil/gas facilities in fuel handling, and coal facilities in emission and waste handling. A complete listing of the default plant staffing levels is presented in Figures 78 through 83. These figures show the staffing levels for heating and cogeneration facilities at the following types of central heating plants: coal-fired stoker and fluidized bed, oil/gas, and coal slurry.

Functional Description. To facilitate the changes in staffing levels, two options were implemented: one for the review, modification, and printing of the staffing levels, and an equivalent one to handle staff salaries (although it is not perceived to be necessary to change the staff salaries since they are automatically adjusted using the appropriate cost indices to the proper levels).

User Interface. As noted earlier, the review of staff levels for operations and maintenance resulted in changed values for the individual categories. However, the changes do not affect operation of the Cost Model. The following describes the use of the addition to the program to modify the staff levels and salaries.

A series of menus guide you through the necessary questions to complete an analysis. The option to update the staff levels and salaries is found under the Update Databases option from the main menu, shown in Figure 84.

The menu shown in Figure 85 allows you to select the Operations Labor Staffing and Wage Information option to update this information.

Boiler Count	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Plant Size	100	200	300	400	500	600	100	150	200	300	400	450	500	600
Plant Manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asst. Plant Mgr														
Plant Engineer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Plant Tech	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	1	1	1	1
Plant Clerk	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Secretary	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Janitor	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5
Shift Supervisor	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Operator	1	1	1	2	2	2	1	1	1	2	2	2	3	3
Asst. Operator	0	0	1	1	2	2	0	0	1	1	2	3	3	3
Laborer														
Yard Sprvsr														
Equip Operator	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	1	1	1	1
Asst. Operator														
Laborer														
Maint Sprvsr	0	0	0	0	0.5	0.5	0	0	0	0	0.5	0.5	0.5	0.5
Mech Mech - A	2	2	2	2	3	3	2	2	2	2	3	3	3	3
Mech Mech - B														
Mech Mech - C														
Elec Mech - A	1	1	1	1	1	1	2	2	2	2	2	2	2	2
Elec Mech - B														
Elec Mech - C														
Laborer	0	0	1	1	2	2	0	0	0	1	1	2	2	2
Total	11.19	11.19	13.19	15.44	18.94	18.94	12.19	12.19	13.19	15.19	18.94	20.94	21.94	21.94

Figure 78. Facility staffing for coal-fired stoker and fluidized bed boilers—heating.

Boiler Count	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Plant Size	100	200	300	400	500	600	100	150	200	300	400	450	500	600
Plant Manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asst. Plant Mgr														
Plant Engineer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Plant Tech	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	1	1	1	1
Plant Clerk	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Secretary	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Janitor	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5
Shift Supervisor	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Operator	1	1	1	2	2	2	1	1	1	2	2	3	3	3
Asst. Operator	0	0	1	1	2	2	0	0	1	1	2	2	3	3
Laborer														
Yard Sprvsr														
Equip Operator	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	1	1	1	1
Asst. Operator														
Laborer														
Maint Sprvsr	0	0	0	0	0.5	0.5	0	0	0	0.5	0.5	0.5	0.5	0.5
Mech Mech - A	2.5	2.5	2.5	2.5	3.5	3.5	2.5	2.5	2.5	2.5	3.5	3.5	3.5	3.5
Mech Mech - B														
Mech Mech - C														
Elec Mech - A	1.5	1.5	1.5	1.5	1.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Elec Mech - B														
Elec Mech - C														
Laborer	0	0	1	1	2	2	0	0	0	1	1	2	2	2
Total	12.19	12.19	14.19	16.44	19.94	19.94	13.19	13.19	14.19	16.69	19.94	21.94	22.94	22.94

Figure 79. Facility staffing for coal-fired stoker and fluidized bed boilers—cogeneration.

Boiler Count	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Plant Size	100	200	300	400	500	600	100	150	200	300	400	450	500	600
Plant Manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asst. Plant Mgr														
Plant Engineer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Plant Tech	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	1	1	1	1
Plant Clerk	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Secretary	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Janitor	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5
Shift Supervisor	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Operator	1	1	1	2	2	2	1	1	1	2	2	3	3	3
Asst. Operator														
Laborer														
Yard Sprvsr														
Equip Operator														
Asst. Operator														
Laborer														
Maint Sprvsr	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5
Mech Mech - A	1	1	1	1	2	2	1	1	1	1	2	2	2	2
Mech Mech - B														
Mech Mech - C														
Elec Mech - A	1	1	1	1	1	1	2	2	2	2	2	2	2	2
Elec Mech - B														
Elec Mech - C														
Laborer	0	0	1	1	2	2	0	0	0	1	1	2	2	2
Total	9.69	9.69	10.69	12.44	14.44	14.44	10.69	10.69	10.69	12.69	14.44	16.94	16.94	16.94

Figure 80. Facility staffing for oil/gas-fired boilers—heating.

Boiler Count	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Plant Size	100	200	300	400	500	600	100	150	200	300	400	450	500	600
Plant Manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asst. Plant Mgr														
Plant Engineer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Plant Tech	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	1	1	1	1
Plant Clerk	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Secretary	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Janitor	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5
Shift Supervisor	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Operator	1	1	1	2	2	2	1	1	1	2	2	3	3	3
Asst. Operator														
Laborer														
Yard Sprvsr														
Equip Operator														
Asst. Operator														
Laborer														
Maint Sprvsr	0	0	0	0	0.5	0.5	0	0	0	0	0.5	0.5	0.5	0.5
Mech Mech - A	1.5	1.5	1.5	1.5	2.5	2.5	1.5	1.5	1.5	1.5	2.5	2.5	2.5	2.5
Mech Mech - B														
Mech Mech - C														
Elec Mech - A	1.5	1.5	1.5	1.5	1.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Elec Mech - B														
Elec Mech - C														
Laborer	0	0	1	1	2	2	0	0	0	1	1	2	2	2
Total	10.69	10.69	11.69	13.44	15.94	15.94	11.69	11.69	11.69	13.69	15.94	17.94	17.94	17.94

Figure 81. Facility staffing for oil/gas-fired boilers—cogeneration.

Boiler Count	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Plant Size	100	200	300	400	500	600	100	150	200	300	400	450	500	600
Plant Manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asst. Plant Mgr														
Plant Engineer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Plant Tech	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	1	1	1	1
Plant Clerk	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Secretary	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Janitor	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5
Shift Supervisor	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Operator	1	1	1	2	2	2	1	1	1	2	2	3	3	3
Asst. Operator	0	0	0	1	1	1	0	0	0	0	1	1	1	1
Laborer														
Yard Sprvsr														
Equip Operator														
Asst. Operator														
Laborer														
Maint Sprvsr	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5
Mech Mech - A	1	1	1	1	2	2	1	1	1	1	2	2	2	2
Mech Mech - B														
Mech Mech - C														
Elec Mech - A	1	1	1	1	1	1	2	2	2	2	2	2	2	2
Elec Mech - B														
Elec Mech - C														
Laborer	0	0	1	1	2	2	0	0	0	1	1	1	2	2
Total	9.69	9.69	10.69	13.44	15.44	15.44	10.69	10.69	10.69	12.69	15.44	16.44	17.94	17.94

Figure 82. Facility staffing for coal slurry boilers—heating.

Boiler Count	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Plant Size	100	200	300	400	500	600	100	150	200	300	400	450	500	600
Plant Manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asst. Plant Mgr														
Plant Engineer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Plant Tech	0.5	0.5	0.5	1	1	1	0.5	0.5	0.5	0.5	1	1	1	1
Plant Clerk	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Secretary	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Plant Janitor	0.25	0.25	0.25	0.5	0.5	0.5	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5
Shift Supervisor	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Operator	1	1	1	2	2	2	1	1	1	2	2	3	3	3
Asst. Operator	0	0	0	1	1	1	0	0	0	0	1	1	1	1
Laborer														
Yard Sprvsr														
Equip Operator														
Asst. Operator														
Laborer														
Maint Sprvsr	0	0	0	0	0.5	0.5	0	0	0	0	0.5	0.5	0.5	0.5
Mech Mech - A	1.5	1.5	1.5	1.5	2.5	2.5	1.5	1.5	1.5	1.5	2.5	2.5	2.5	2.5
Mech Mech - B														
Mech Mech - C														
Elec Mech - A	1.5	1.5	1.5	1.5	1.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Elec Mech - B														
Elec Mech - C														
Laborer	0	0	1	1	2	2	0	0	0	1	1	2	2	2
Total	10.69	10.69	11.69	14.44	16.94	16.94	11.69	11.69	11.69	13.69	16.94	18.94	18.94	18.94

Figure 83. Facility staffing for coal slurry boilers—cogeneration.

Central Heating Plant Economics Evaluation Program 08/01/92
Main Menu

1 -- Screening Models	6 -- Update Databases
2 -- Cost Models	7 -- System Utilities
3 -- Multiple Run Analysis	
4 -- Sensitivity Analysis	
5 -- Load Sensitivity Analysis	Q -- Quit (exit program)

Use ↑↓ to move highlight or enter first character to select option

Add/edit the background information stored in database files

Figure 84. Initial menu screen for CHPECON.

Central Heating Plant Economics Evaluation Program 08/01/92
Main menu -- update data

1 -- Coal Field Information
2 -- Acceptable Coal Properties Information
3 -- Military Base Information
4 -- Boiler Stack Emission Regulations
5 -- Equipment Emission Factors
6 -- Construction Productivity and Wage Information
7 -- Operations Labor Staffing and Wage Information

8 -- Copy INVENTORY site info to Military Base Info

Q -- Quit (return to main menu)

Use ↑↓ to move highlight or enter first character to select option

Enter/modify staff requirements and wages for technologies and size ranges

Figure 85. Menu screen for update data options.

After selecting this option, the menu shown in Figure 86 allows you to either edit or print staff levels or staff salaries. The Quit option returns the screen to the previous CHPECON Update Databases menu.

Selecting the first option, Edit staff levels, brings up the display and editing screen shown in Figure 87. The menu in the lower right corner is active when displaying entries. Next entry moves to a larger PMCR entry, or a larger number of boilers, or a different boiler type and mode of operation, depending on where you are in the

database. Previous entry reverses the direction of Next entry. Either is disabled when you can proceed no further in that direction. For example, Previous entry is disabled when this option is first entered because the pointer is already at the first entry (i.e., there is no previous entry to the first).

```
Central Heating Plant Economics Evaluation Program 08/01/92

                    ************************
                    * Edit staff levels    *
                    * Print staff levels   *
                    * Edit staff salaries  *
                    * Print staff salaries *
                    * -------------------- *
                    * Quit                 *
                    ************************
```

Figure 86. O&M labor staff levels and staff salary menu.

```
          Type: coal boiler, heating          Boilers: 3 PMCR <= 300000 lbs/hr

------- Management --------------- Maintenance ------------ Steam Dist -------
                                *                          *
  Plant Manager...  1.00        *  Supervisor.....  0.00   *  Supervisor.....  0.00
  Asst. Plant Mgr.  0.00        *  Mech Maint - A.  3.00   *  Mech Maint - A.  0.00
  Plant Engineer..  2.00        *  Mech Maint - B.  0.00   *  Mech Maint - B.  0.00
  Plant Technician  1.00        *  Mech Maint - C.  0.00   *  Mech Maint - C.  0.00
  Plant Clerk.....  1.00        *  Elec Maint - A.  2.00   *  Elec Maint - A.  0.00
  Plant Secretary.  1.00        *  Elec Maint - B.  0.00   *  Elec Maint - B.  0.00
  Plant Janitor...  1.00        *  Elec Maint - C.  0.00   *  Elec Maint - C.  0.00
                                *  Maint Laborer..  1.00   *  Equipment Optr.  0.00
                                *                          *  Asst Eq Optr...  0.00
                                *                          *  Laborer........  0.00
------- Operations -------------*                          *
                                *------ Fuel Storage ------*
  Shift Supervisor  0.00        *                          *  *****************
  Boiler Operator.  4.00        *  Supervisor.....  0.00   *  * Next entry     *
  Asst Blr Optr...  4.00        *  Equipment Optr.  1.00   *  * Previous entry *
  Boiler Laborer..  1.00        *  Asst Eq Optr...  1.00   *  * Edit entry     *
                                *  Fuel Laborer...  2.00   *  * Add entry      *
                                *                          *  * Delete entry   *
                                *                          *  * Quit           *
                                *                          *  *****************
```

Figure 87. O&M labor staff levels display and editing screen.

Edit entry allows you to edit the entry that is shown. The cursor can be moved between entries with the arrow keys. The menu in the lower right changes to a two-valued selection. Selecting Accept changes saves the modifications to the database. Selecting Original values restores the entries that were present before you began making changes. Once either of these is selected, the program returns to the display of the entry with the complete menu in the lower right.

Add entry allows you to add a new entry to the database. After selecting this option, a list of boiler/operating modes is shown in the middle of the screen as in Figure 88. Selecting is done with the highlighting bar and the cursor keys. After selecting from this list, the list is overlaid with the number of boilers selection as shown in Figure 89. After selecting either 3 boilers or 4 or 5 boilers, this list is overlaid with an entry field for the maximum size of the option, as shown in Figure 90. The entry is rounded to the

nearest 5000 lb steam/hr. You can confirm the addition by answering "Y." After this, the entry is added and the program returns to the menu (Figure 87).

```
        Type: coal boiler, heating          Boilers: 3 PMCR <= 300000 lbs/hr

------- Management --------------- Maintenance ----------- Steam Dist -------
                                *                        *
  Plant Manager...  1.00    *  Supervisor.....  0.00 *  Supervisor.....  0.00
  Asst. Plant Mgr.  0.00    *  Mech Maint - A.  3.00 *  Mech Maint - A.  0.00
  Plant Engineer..  2.00    *  Mech Maint - B.  0.00 *  Mech Maint - B.  0.00
  Plant Technician ************************************** h Maint - C.   0.00
  Plant Clerk.....  * coal-fired boiler, heating         * c Maint - A.   0.00
  Plant Secretary.  * slurry-fired boiler, heating       * c Maint - B.   0.00
  Plant Janitor...  * coal-fired boiler, cogeneration    * c Maint - C.   0.00
                    * slurry-fired boiler, cogeneration  * ipment Optr.   0.00
                    * oil/gas-fired boiler, heating      * t Eq Optr...   0.00
                    * oil/gas-fired boiler, cogeneration * orer........   0.00
------- Operations -**************************************
                            *------ Fuel Storage ----*
  Shift Supervisor  0.00    *                        *   *****************
  Boiler Operator.  4.00    *  Supervisor.....  0.00 *   * Next entry     *
  Asst Blr Optr...  4.00    *  Equipment Optr.  1.00 *   * Previous entry *
  Boiler Laborer..  1.00    *  Asst Eq Optr...  1.00 *   * Edit entry     *
                            *  Fuel Laborer...  2.00 *   * Add entry      *
                            *                        *   * Delete entry   *
                            *                        *   * Quit           *
                            *                        *   *****************
```

Figure 88. Boiler type and operating mode selection.

```
        Type: coal boiler, heating          Boilers: 3 PMCR <= 300000 lbs/hr

------- Management --------------- Maintenance ----------- Steam Dist -------
                                *                        *
  Plant Manager...  1.00    *  Supervisor.....  0.00 *  Supervisor.....  0.00
  Asst. Plant Mgr.  0.00    *  Mech Maint - A.  3.00 *  Mech Maint - A.  0.00
  Plant Engineer..  2.00    *  Mech Maint - B.  0.00 *  Mech Maint - B.  0.00
  Plant Technician ************************************** h Maint - C.   0.00
  Plant Clerk.....  * coal-fired boiler, heating         * c Maint - A.   0.00
  Plant Secretary.  * slurry ****************** g        * c Maint - B.   0.00
  Plant Janitor...  * coal-f * 3 boilers      * tion     * c Maint - C.   0.00
                    * slurry * 4 or 5 boilers * ration   * ipment Optr.   0.00
                    * oil/ga ****************** ng       * t Eq Optr...   0.00
                    * oil/gas-fired boiler, cogeneration * orer........   0.00
------- Operations -**************************************
                            *------ Fuel Storage ----*
  Shift Supervisor  0.00    *                        *   *****************
  Boiler Operator.  4.00    *  Supervisor.....  0.00 *   * Next entry     *
  Asst Blr Optr...  4.00    *  Equipment Optr.  1.00 *   * Previous entry *
  Boiler Laborer..  1.00    *  Asst Eq Optr...  1.00 *   * Edit entry     *
                            *  Fuel Laborer...  2.00 *   * Add entry      *
                            *                        *   * Delete entry   *
                            *                        *   * Quit           *
                            *                        *   *****************
```

Figure 89. Number of boilers selection.

```
          Type: coal boiler, heating          Boilers: 3 PMCR <= 300000 lbs/hr

------- Management ---------------- Maintenance ----------- Steam Dist -------
                               *                        *
  Plant Manager...  1.00    *  Supervisor.....  0.00 *  Supervisor.....  0.00
  Asst. Plant Mgr.  0.00    *  Mech Maint - A.  3.00 *  Mech Maint - A.  0.00
  Plant Engineer..  2.00    *  Mech Maint - B.  0.00 *  Mech Maint - B.  0.00
  Plant Technician  *****************************************h Maint - C.  0.00
  Plant Clerk.....  * coal-fired boiler, heating              * Maint - A.  0.00
  Plant Secretary.  ***************************************** Maint - B.  0.00
  Plant Janitor...  * Enter upper PMCR range:  80,000 lb/lr *  Maint - C.  0.00
                    *    Accept entry? N                    * pment Optr.  0.00
                    *****************************************  Eq Optr...  0.00
                    * oil/gas-fired boiler, cogeneration   * orer........  0.00
------- Operations -****************************************
                               *------ Fuel Storage -------*
  Shift Supervisor  0.00    *                            *    *****************
  Boiler Operator.  4.00    *  Supervisor.....  0.00     *    * Next entry     *
  Asst Blr Optr...  4.00    *  Equipment Optr.  1.00     *    * Previous entry *
  Boiler Laborer..  1.00    *  Asst Eq Optr...  1.00     *    * Edit entry     *
                            *  Fuel Laborer...  2.00     *    * Add entry      *
                            *                            *    * Delete entry   *
                            *                            *    * Quit           *
                            *                            *    *****************
```

Figure 90. Facility size for staff levels.

Delete entry allows you to delete the currently shown entry. Selecting this option brings up a message window asking you to confirm this deletion before proceeding. If the entry is deleted, the program displays an entry that is adjacent in the database.

Quit returns the screen to the general menu (Figure 86).

At the general menu (Figure 86), selecting the Print staff levels option causes the program to immediately start printing the requested information. The staff levels information consists of multiple pages, each for a particular boiler type and operation, number of boilers, and maximum facility size. You can stop printing before the end by pressing the <Esc> key; this option is indicated on the screen.

Selecting the Edit staff salaries option brings up a screen (Figure 91) similar to the Edit staff levels option. It consists of only the one screen because the hourly salaries are applicable to all the staffing levels of the previous screens. Its menu is simpler as a result, consisting of only the options to Accept changes (to save the modifications) or Original values (to revert back to the previously stored values).

```
                     Operating and Maintenance Staff Salary Update

------- Management ---------------- Maintenance ----------- Steam Dist -------
                           *                          *
  Plant Manager... 26.50   *  Supervisor.....   0.00  *  Supervisor.....   0.00
  Asst. Plant Mgr.  0.00   *  Mech Maint - A.  13.00  *  Mech Maint - A.   0.00
  Plant Engineer.. 22.00   *  Mech Maint - B.   0.00  *  Mech Maint - B.   0.00
  Plant Technician 16.50   *  Mech Maint - C.   0.00  *  Mech Maint - C.   0.00
  Plant Clerk..... 12.00   *  Elec Maint - A.  13.00  *  Elec Maint - A.   0.00
  Plant Secretary. 10.50   *  Elec Maint - B.   0.00  *  Elec Maint - B.   0.00
  Plant Janitor...  8.25   *  Elec Maint - C.   0.00  *  Elec Maint - C.   0.00
                           *  Maint Laborer..   8.50  *  Equipment Optr.   0.00
                           *                          *  Asst Eq Optr...   0.00
                           *                          *  Laborer........   0.00
------- Operations --------*                          *
                           *------ Fuel Storage ----*
  Shift Supervisor 17.00   *                          *
  Boiler Operator. 12.00   *  Supervisor.....   0.00  *
  Asst Blr Optr... 10.00   *  Equipment Optr.  10.00  *
  Boiler Laborer..  8.50   *  Asst Eq Optr...   9.00  *
                           *  Fuel Laborer...   8.50  *
                           *                          *   < Accept changes  >
                           *                          *   < Original values >
                           *                          *
```

Figure 91. O&M labor staff salaries display/editing screen.

Selecting the Print staff salaries option causes the program to start to print the requested information, which is a one-page printout.

Review of Output. An example of one page of the staff levels printout is shown in Figure 92.

The salary information is a one-page printout, as shown in Figure 93.

```
                 CHPECON -- Operation & Maintenance Staff Levels
Printed: 08/01/92 Page 18 of 79

 Facility Type: coal-fired boiler, heating
PMCR less than or equal to 450000 lbs/hr: Number of Boilers: 4 or 5

      Title                    Quantity
Management:
 Plant Manager                   1.00
 Assist. Plant Manager           0.00
 Plant Engineer                  2.00
 Plant Technician                2.00
 Plant Clerk                     1.00
 Plant Secretary                 1.00
 Plant Janitor                   1.00

Operations:
 Shift Supervisor                1.00
 Operator                        6.00
 Assist. Operator                4.00
 Laborer                         3.00

Fuel Storage:
 Yard Supervisor                 0.00
 Operator Equipment              2.00
 Assist. Operator                1.00
 Laborer                         2.00

Maintenance:
 Maint. Supervisor               0.00
 Mech. Maintenance:
   A - Mechanic                  3.00
   B - Mechanic                  0.00
   C - Mechanic                  0.00
 Elec. Maintenance:
   A - Mechanic                  3.00
   B - Mechanic                  0.00
   C - Mechanic                  0.00
 Laborer                         3.00

Steam Dist. System:
 Supervisor                      0.00
 Mech. Maintenance
    A - Mechanic                 0.00
    B - Mechanic                 0.00
    C - Mechanic                 0.00
 Elec. Maintenance
    A - Mechanic                 0.00
    B - Mechanic                 0.00
    C - Mechanic                 0.00
 Equip. Operator                 0.00
 Assist. Operator                0.00
 Laborer                         0.00
```

Figure 92. Example O&M labor staff levels print output.

```
                CHPECON -- Operation & Maintenance Salary Levels
Printed: 08/01/92 Page 1 of 1

      Title                    Salary
Management:
 Plant Manager                 26.50
 Assist. Plant Manager          0.00
 Plant Engineer                22.00
 Plant Technician              16.50
 Plant Clerk                   12.00
 Plant Secretary               10.50
 Plant Janitor                  8.25

Operations:
 Shift Supervisor              17.00
 Operator                      12.00
 Assist. Operator              10.00
 Laborer                        8.50

Fuel Storage:
 Yard Supervisor                0.00
 Operator Equipment            10.00
 Assist. Operator               9.00
 Laborer                        8.50

Maintenance:
 Maint. Supervisor              0.00
 Mech. Maintenance:
   A - Mechanic                13.00
   B - Mechanic                 0.00
   C - Mechanic                 0.00
 Elec. Maintenance:
   A - Mechanic                13.00
   B - Mechanic                 0.00
   C - Mechanic                 0.00
 Laborer                        8.50

Steam Dist. System:
 Supervisor                     0.00
 Mech. Maintenance
    A - Mechanic                0.00
    B - Mechanic                0.00
    C - Mechanic                0.00
 Elec. Maintenance
    A - Mechanic                0.00
    B - Mechanic                0.00
    C - Mechanic                0.00
 Equip. Operator                0.00
 Assist. Operator               0.00
 Laborer                        0.00
```

Figure 93. Example O&M labor staff salaries print output.

Inventory Database Access

This section of the program allows interaction between the CHPECON program and the inventory system database. The rationale for this is that access to the background information of a given military site that has been collected and stored within the inventory system database would allow you to enter thermal loads and electrical loads without manual input. Doing so potentially increases the speed of operation and reduces the chance of error in manual entry of a long string of numbers.

Functional Description of Implementation

The basic approach for implementing Inventory Database Access consists of three parts:

1. Access to the inventory database for site and weather information to update the military base database in CHPECON.
2. Access to the inventory database for thermal loads to provide a starting point for the load input of the screening model.
3. Access to the inventory database for electrical loads to provide a starting point for the load input of the screening model.

The first item should be done whenever a new site is being considered, if it is not already in place in the military installation database. The other two simply act on your request for information by reading the data stored in the inventory files to be used as default entries for the loads instead of 0. You can modify those values as necessary.

The implementation of this feature required the modification of the screening model module to access the look-up modules, and the database update menu module to access the site information copy module.

After careful consideration, it was decided that the data checking and cross-indexing functions would be better handled by the inventory database program.

NOTE: This function works only: IF the inventory database program continues to be run under FoxPro, IF the inventory database program continues to update the index files for the database files, and IF the files are placed in the same directory as CHPECON. If these conditions change, this function will no longer operate properly.

User Interface

The user interface is based on the format as developed in CHPECON. Access to the first part of this implementation is shown in Figure 94, with the new option to Copy INVENTORY site info to Military Base Info as part of the update database menu.

```
Central Heating Plant Economics Evaluation Program 08/01/92
Main menu -- update data

1 -- Coal Field Information
2 -- Acceptable Coal Properties Information
3 -- Military Base Information
4 -- Boiler Stack Emission Regulations
5 -- Equipment Emission Factors
6 -- Construction Productivity and Wage Information
7 -- Operations Labor Staffing and Wage Information
8 -- Copy INVENTORY site info to Military Base Info
Q -- Quit (return to main menu)
Use ↑↓ to move highlight or enter first character to select option
---------------------------------------------------------------------------
Select entries from INVENTORY site file for CHPECON Military Base Info
```

Figure 94. Update database menu screen for CHPECON.

Once this option is selected, the program displays a list of the sites that are available in the inventory database (Figure 95). Use the cursor keys (<Up>, <Down>, <PgUp>, and <PgDn>), or begin to enter the name of the facility. Entering the name allows rapid movement through the database listing. As each letter is entered, the program attempts to move to the first available entry that matches the letter. If it is successful, the highlight bar advances. If it is not successful, the newly entered letter is discarded because it does not lead to an existing entry. The letters entered and accepted are shown on the lowest screen line. The backspace key can be used to remove letters, or by pausing a few seconds, the program will automatically clear the search string, allowing you to start again.

```
      Select INVENTORY installation to be copied
***********************************************************************
*      MCALESTER ARMY AMMUNITION PLANT                                *
*      MILAN ARMY AMMUNITION PLANT                                    *
*      MISSISSIPPI ARMY AMMUNITION PLANT                              *
*      MONTEREY, PRESIDIO OF                                          *
*      NATICK RESEARCH AND DEVELOPMENT CENTER                         *
*      NAVAJO DEPOT ACTIVITY CLOSURE                                  *
*      NEW CUMBERLAND ARMY DEPOT                                      *
*      NEWPORT ARMY AMMUNITION PLANT                                  *
*      OAKLAND ARMY BASE (MTMC WESTERN AREA)                          *
*      PHOSPHATE DEVELOPMENT WORKS                                    *
*      PICATINNY ARSENAL                                              *
*      PINE BLUFF ARSENAL                                             *
*      PUEBLO DEPOT ACTIVITY REALIGNMENT                              *
*      RADFORD ARMY AMMUNITION PLANT                                  *
*      RAVENNA ARMY AMMUNITION PLANT                                  *
*      RED RIVER ARMY DEPOT                                           *
*      REDSTONE ARSENAL                                               *
*      RIVERBANK ARMY AMMUNITION PLANT                                *
*      ROCK ISLAND ARSENAL                                            *
*      ROCKY MOUNTAIN ARSENAL                                         *
** Use <↑> <↓> <PgUp> <PgDn>, <Enter> to accept, <Esc> to quit ********
   or type in search string{}
```

Figure 95. Inventory database site list for selection.

An example shows how this technique is used. If you want to select the Pine Bluff Arsenal (an entry shown in the middle of Figure 95), entering a “P” moves the highlight bar to the Phosphate Development Works entry, the first entry that matches “P.” Entering an “I” advances the highlight bar to the Picatinny Arsenal entry, the first that matches “PI.” Entering an “N” advances the highlight bar to the desired Pine Bluff Arsenal entry, matching the “PIN” entry. By typing the first few letters of the site name, a site can be highlighted quickly. Alternatively, you can combine the letter entry method with cursor keys.

Pressing the <Esc> key will cause the program to exit without copying. Indicate that the highlighted site should be copied by pressing the <Enter> key. After pressing <Enter>, the program asks you to confirm your choice, as shown in Figure 96. If you confirm, the program asks if the entry is an Army base (Yes or No), in the same window in the middle of the screen. Once you answer, the program returns to the menu shown in Figure 94.

The copied site information can then be edited with the Military Base Information option of the Update Databases menu.

```
Select INVENTORY installation to be copied
   ***********************************************************************
   *      MILAN ARMY AMMUNITION PLANT                                    *
   *      MISSISSIPPI ARMY AMMUNITION PLANT                              *
   *      MONTEREY, PRESIDIO OF                                          *
   *      NATICK RESEARCH AND DEVELOPMENT CENTER                         *
   *      NAVAJO DEPOT ACTIVITY CLOSURE                                  *
   *      NEW CUMBERLAND ARMY DEPOT                                      *
   *      NEWPORT ARMY AMMUNITION PLANT                                  *
   *      OAK**************************************************          *
   *      PHO*                                                *          *
   *      PIC*            Copy installation? (Y/N) N          *          *
   *      PIN*                                                *          *
   *      PUE**************************************************          *
   *      RADFORD ARMY AMMUNITION PLANT                                  *
   *      RAVENNA ARMY AMMUNITION PLANT                                  *
   *      RED RIVER ARMY DEPOT                                           *
   *      REDSTONE ARSENAL                                               *
   *      RIVERBANK ARMY AMMUNITION PLANT                                *
   *      ROCK ISLAND ARSENAL                                            *
   *      ROCKY MOUNTAIN ARSENAL                                         *
   *      SACRAMENTO ARMY DEPOT                                          *
   ** Use <↑> <↓> <PgUp> <PgDn>, <Enter> to accept, <Esc> to quit ********
      or type in search string{}
```

Figure 96. Confirmation of site information copy.

The second part of this function has been integrated with the rest of the screening model of CHPECON. Only the changes required to incorporate this function are discussed below.

When running the screening model, the program searches for the presence of the inventory database files and, if found, asks you if the files should be searched for thermal load entries as shown in Figure 97. If you indicate yes, the program attempts to find a site name matching the base name from MILBASE.DBF. If a match is found, the program uses this entry. If a match is not found, the system asks you to indicate the proper entry using a selection screen as shown in Figure 95.

```
Use INVENTORY file thermal use data? (Y/N) Y

Found a matching name for the installation in the
INVENTORY installation file.  Using this entry...

Continue with INVENTORY data? Y
```

Figure 97. Query concerning use of INVENTORY data.

Once the INVENTORY site has been selected, the program asks if multiple load entries should be combined (only if more than one was found), as shown in Figure 98.

```
Use INVENTORY file thermal use data? (Y/N) Y

Found a matching name for the installation in the
INVENTORY installation file.  Using this entry...

6 plants exist in the INVENTORY file.
Combine some / all into a composite for the site? (Y/N) N
```

Figure 98. Query concerning combining multiple plant data.

If you indicate that data should be combined, the program presents the screen in Figure 99 for the selection of the individual plants and the annual data. As noted on the screen, any entry selected has a year associated with it (in the brackets). An unselected entry has a blank year, and an entry without any annual data has a year of "XXXX." Select a plant by pressing the <Enter> key while it is highlighted. A second popup menu is displayed for you to select the year of the data, as shown in Figure 100. Once selected, the program reverts to the display of Figure 99 for further selection. Pressing the <Esc> key indicates that you are done with this process and the screening evaluation should continue.

```
Select plant to include in heating combination, then select the year
of CHP data to be included (selecting the plant again unselects it).
Selected plants have the selected data's year after their name.
Any plant with the year XXXX has no data
Press <Esc> when complete
     ******************************
     * BLDG 311             [    ] *
     * BLDG 2351            [    ] *
     * BLDG 2369            [XXXX] *
     * BLDG 745             [    ] *
     * BLDG 1021            [XXXX] *
     * BLDG 645             [    ] *
     ******************************
```

Figure 99. Plant load data selection screen.

```
Select plant to include in heating combination, then select the year
of CHP data to be included (selecting the plant again unselects it).
Selected plants have the selected data's year after their name.
Any plant with the year XXXX has no data
Press <Esc> when complete
     ******************************
     * BLDG 311             [1990] *     ********
     *▸BLDG 2351            [    ] *     * 1989 *
     * BLDG 2369            [XXXX] *     * 1990 *
     * BLDG 745             [    ] *     ********
     * BLDG 1021            [XXXX] *
     * BLDG 645             [    ] *
     ******************************
```

Figure 100. Plant and year load data selection screen.

As the program continues, you are presented with the thermal load entry screen from the screening model, allowing modification of the data retrieved from the inventory database.

If you are running a screening analysis of a cogeneration or third-party cogeneration facility, an additional display asks if the available electrical load data should be accessed. Because electrical data was collected on a site-wide basis, you only need to provide the year to be used for the load data as shown in Figure 101. As for the thermal data, you are presented with the electrical load entry screen to permit modification of the retrieved data.

```
Highlight year to use, then press <Enter>

          ********
          * 1989 *
          * 1990 *
          ********
```

Figure 101. Year electrical load data selection screen.

Review of Output

This option does not change the output from the screening model.

Gas-/Oil-Fired Summer Boiler Evaluation

This option expands the capability of the existing cost estimating model to include the capital and operating and maintenance costs of a "summer" boiler used to meet heating demands during low load periods, typically during the summer months.

Functional Description of Implementation

The possibility of using a small, gas- or oil-fired boiler for supplying steam during the lower demand periods of the summer months is explored through this addition to CHPECON. It was considered as a practical alternative to running one of the coal-fired boilers at or near its minimum operating level, in view of the fact that this would be at its most inefficient condition and may still produce more steam than is needed for the given site conditions (causing steam to be dumped as it was generated). The use of one of these boilers would lower the minimum steam flow that could be produced, and widen the range of operation at the lower end as a result of the greater turndown capabilities of gas/oil boilers compared to coal boilers.

This evaluation considers one of two user-selected possibilities: either a package boiler sized to meet the summer needs, or a modification of one of the existing boilers to permit firing alternatives to coal. In practice, the modification could consist of installing new burners and associated equipment.

Evaluation of summer boiler operation is integrated with the costing model in CHPECON. After indicating that a summer boiler should be considered as part of the cost analysis, you need to indicate which months should be included for running the summer boiler. This flexibility allows you to include only the desired months in the evaluation.

As a result of its incorporation into the costing model, the summer boiler evaluation requires that a screening model case already exist for the military base that is to be studied. This ensures that the basic information about the facility (heating load requirements, location, and type of system) is present.

After the costing model has been run, if you have indicated that a summer boiler be considered, CHPECON re-evaluates the life cycle cost and its components using a summer boiler to displace the energy costs during the selected months.

Programmatic Description of Implementation

Because the option to consider use of a summer boiler has been integrated into the costing model of CHPECON, the overall size of the program is kept to a minimum. Including this option required modification of some of the costing modules to include the question about using a summer boiler and calling the appropriate modules. No additional files are generated during the summer boiler operation analysis. The output for this option is included in the costing model report that is generated.

The required capacity of the summer boiler is calculated by determining the maximum average monthly steam flow for the range of operating months and multiplying this by the ratio of the yearly maximum average monthly steam flow and the plant maximum continuous rating. In this way, there is enough capacity to meet the swings in demand that make up the average steam flow.

User Interface

The user interface for this option is based on the format as developed in CHPECON. A series of menus guide you through the necessary questions to complete an analysis. Only the variations in the use of CHPECON due to the inclusion of the summer boiler evaluation will be reviewed here, because the cost analysis section of the program is the same as the Cost Model selection:

After selecting the Costing Model from the initial menu for CHPECON, the type of system, and the site to be analyzed, you answer questions related to the cost model, arriving at the screen shown in Figure 102. The summer boiler can be skipped by answering "N." If you answer "Y" to include a summer boiler, the screen in Figure 103 is shown.

```
                Central Heating Plant Economics Evaluation Program 08/01/92
                          Economic Analysis Input New plant (NP)

  Use a summer boiler? (Y/N)  Y

 Would you like to change any of the values on this screen? N
```

Figure 102. Screen prompt for including summer boiler use in costing model analysis.

```
                    Summer boiler operating range

           April:                  Summer boiler size needed:
             May: 54,000 lb/hr
            June:  ◂*S*▸
            July:   * *
          August:   *E*            Existing boiler can be modified
       September:
         October:


  Use the cursor keys [↑↓] to move the pointer
  Press [S] to indicate the start of the summer boiler operation
  Press [E] to indicate the end of the summer boiler operation
  Press [Enter] to indicate the start and end are acceptable
```

Figure 103. Input screen for summer boiler period of operation.

Use the <Up> and <Down> keys to move the highlight area between the limits of April and October. Pressing "S" sets the start of the operating period to the cursor location. Pressing "E" sets the end of the operation period to the cursor location. If the selected end is earlier than the selected start, the start is automatically moved to the end. If the selected start is later than the selected end, the end is automatically moved to the start.

As the starting and ending points are adjusted, CHPECON updates the screen with the required capacity of the summer boiler and whether one of the existing boilers' capacity fits this value. You can then modify the unit with additional burners to result in the summer boiler. Figure 103 shows the screen when an existing boiler can be used for summer boiler operation; Figure 104 shows the screen display when the summer boiler capacity is larger than a single existing boiler and modification of an existing boiler is no longer an option.

```
                    Summer boiler operating range

           April:                  Summer boiler size needed:
             May:  ◂*S*▸ 77,000 lb/hr
            June:   * *
            July:   * *
          August:   * *            Existing boiler CANNOT be modified
       September:   *E*
         October:


  Use the cursor keys [↑↓] to move the pointer
  Press [S] to indicate the start of the summer boiler operation
  Press [E] to indicate the end of the summer boiler operation
  Press [Enter] to indicate the start and end are acceptable
```

Figure 104. Example of summer boiler capacity exceeding existing boiler capacity.

Once the summer boiler's period of operation is set, pressing the <Enter> key brings up a small menu on the left side of the screen, as shown in Figure 105. This allows you to select the option to use a new gas-/oil-fired summer boiler, modify an existing boiler, or switch back to using no summer boiler. You can also select the option to change the starting and ending values again. If the months of operation selected result in the inability to modify an existing boiler to meet the summer boiler design capacity

requirements, the Modify existing boiler option is displayed, at a low intensity screen color, indicating that it cannot be selected.

```
                    Summer boiler operating range

      **************************  Summer boiler size needed:
      * Use new boiler          * 71,000 lb/hr
      * Modify existing boiler *
      * No summer boiler        *
      **************************  Existing boiler can be modified
      * Change values           *
      **************************


    Use the cursor keys [↑↓] to move the pointer
    Press [S] to indicate the start of the summer boiler operation
    Press [E] to indicate the end of the  summer boiler operation
    Press [Enter] to indicate the start and end are acceptable
```

Figure 105. Screen for selecting type of summer boiler operation.

Once you select the option for summer boiler implementation, the program continues with the rest of the cost model. At the end of the cost model, the summer boiler option adds two series of calculations for the option being considered. The first calculation documents the changes in energy costs by substituting oil for coal, and the second documents the changes in energy costs by substituting natural gas for coal.

As previously, the cost model offers the option of printing the short format, the long format, or both formats of the cost report at the end of the run. Alternatively, the reports that have been generated and stored can be accessed for printing through the Print report option of the cost model menu.

Review of Output

Table 24 is an example of the output from the summer boiler option of the cost model analysis. It consists of the basic details about the summer boiler, including the required boiler long term fuel storage (in days) and tank capacity (in gallons). The listed costs are integrated with the other capital and installation costs.

An example of the details about the costs for using the summer boiler are shown in Table 25 and include annual displaced coal cost, alternate fuel cost, and the net difference. The displaced coal cost is the amount that is not spent on consuming coal in running the coal-fired boiler. The alternate fuel cost (either oil or natural gas) is the amount that is spent on running the summer boiler to meet the average monthly steam flow needs for the site. The net difference is the cost that is added to the life cycle cost for using the summer boiler.

Table 24. Example of output for costs from summer boiler option—new boiler, long format report.

Required summer boiler oil long term storage: 30 days

...

Summer boiler oil storage tank capacity: 661000 gal

...

Summer boiler capital costs: $ 517,941
  Summer boiler (75 k-lb stm/hr)

Summer boiler stack capital costs: $ 10,970

Cost of summer boiler feedwater pumps: $ 19,044
Cost of long term oil storage: $ 157,014
  Cost of long term storage tanks: $ 125,517
  Cost of long term storage-other: $ 31,496

Cost of oil (day storage) pumps: $ 4,388
Cost of oil (day storage) heaters: $ 4,336
Cost of SB day storage tanks: $ 17,326

Cost of oil unloading pumps: $ 13,791
Cost of [3] oil transfer pumps: $ 6,582

...

Summer boiler direct labor cost: $ 370,308
Summer boiler freight cost: $ 22,541
Summer boiler bulk material cost: $ 187,848

Summer boiler installed cost: $ 1,332,094

Table 25. Example of output for costs from summer boiler option—cash flow summary, long format report.

Summer boiler operation: May -- September

Year	Coal Cost Displaced	Oil Cost	Net Cost
1995	415,778	1,240,207	824,428
1996	418,134	1,309,042	890,907
1997	421,881	1,364,428	942,546
1998	426,222	1,422,223	996,000
1999	429,085	1,452,744	1,023,659
2000	433,701	1,510,858	1,077,157
2001	437,694	1,548,755	1,111,061
2002	442,888	1,593,361	1,150,473
2003	447,783	1,626,221	1,178,438
2004	451,787	1,674,321	1,222,534

Table 26 shows a sample of the program's output for detailing the costs of modifying an existing boiler for oil or natural gas firing. This information is more detailed (equipment is not self-contained), and this option requires more components and additional setup than would otherwise be needed.

Table 26. Example of output segment for costs from summer boiler option—existing boiler modification, long format report.

```
Burner (summer use) capital costs: $ 122,884
  Summer burner use (2 for 105 k-lb stm/hr total)

Burner (summer use) master controller: $ 4,179
Burner (summer use) O2 trim system: $ 8,358
Burner (summer use) flow meter: $ 2,298
Burner (summer use) temperature recorder: $ 2,298
Cost of long term oil storage: $ 197,183
  Cost of long term storage tanks: $ 160,439
  Cost of long term storage-other: $ 36,744
Cost of oil (day storage) pumps: $ 4,388
Cost of oil (day storage) heaters: $ 5,119
Cost of SB day storage tanks: $ 20,202
Cost of oil unloading pumps: $ 13,791
Cost of [3] oil transfer pumps: $ 6,582
...
Summer boiler direct labor cost: $ 154,159
Summer boiler freight cost: $ 11,104
Summer boiler bulk material cost: $ 92,538

Summer boiler installed cost: $ 627,954
```

9 System Utilities

The Systems Utilities option accesses those functions that are useful, but are not part of the other functions grouped under Screening Models, Cost Models, and Update Databases. The utilities make the program easier to use, more compatible with available printers, and can fix problems. Figure 106 shows the display screen for System Utilities. Select one of the options by entering the number or letter associated with that option.

```
            Central Heating Plant Economics Evaluation Program          11/19/92
                                System Utilities
      1 -- Set screen colors
      2 -- Set printer margins (limits)
      3 -- Reindex files
      4 -- Rebuild case list file from present files
      5 -- Read in new LCCID cost information
      6 -- Set values for sensitivity analysis
      7 -- Set default values for cost model
      Q -- Quit (return to main menu)

    Use ↑ ↓ to move highlight or enter first character to select option

          Set colors for normal display and entry fields
```
Figure 106. System utilities menu.

Set Screen Colors

Selecting this option results in the screen display shown in Figure 107, which allows you to select the most visible and most usable colors. Using the default colors of white on black and black on white is usually not acceptable on color monitors when other colors are easier to read and less tiring on the eyes. On monochrome systems, however, only black, blue (which shows as an underline) and white can be displayed, with the other colors usually resulting in white. On some liquid crystal displays (LCDs, used in many portables) black characters on a white background (the default used for input fields) is barely legible. On other systems, colors are represented by various shades of gray. This option eliminates the problem of having less than optimal color scheme for all displays.

```
  Normal text color          Highlighted color

--Normal text color--        --Highlighted color--          -Border-
Black          >>Black       Black           Black         >>Black
Black            Blue        Blue          >>Blue            Blue
Green            Green       Green           Green           Green
Cyan             Cyan        Cyan            Cyan            Cyan
Red              Red         Red             Red             Red
Magenta          Magenta     Magenta         Magenta         Magenta
Brown            Brown       Brown           Brown           Brown
White            White       White           White           White
Gray                         Gray
Lt Blue                      Lt Blue
Lt Green                     Lt Green
♦ Lt Cyan                    Lt Cyan
Lt Red                       Lt Red
Lt Magenta                   Lt Magenta
Yellow                     >>Yellow
Lt White                     Lt White

          ↑↓ to select colors, ←→ to switch columns,
          <ENTER> to accept new colors
```
Figure 107. Screen color setup display.

The top part of the screen is an example of the way text will be displayed. All messages, menus, reports, and questions are displayed using the normal text colors. The highlighted colors are used for input fields and for the light bars used to select items. The outer ring represents the border. Some older monitor cards did not allow a separate border; and some newer displays (like LCDs) do not have a border.

The light bar is initially displayed on the foreground normal text color (foreground is the actual text; background is the color surrounding the characters). To select a different color, use the up and down arrows to move the light bar to the desired color. Use the left and right arrows to move between columns. Next to the normal text foreground is the normal text background column. The next columns are the highlighted foreground and background, and the border color. When the desired colors are shown, press the <ENTER> key to reset the entire screen and return to the System Utilities menu. These colors will remain in effect until they are changed, or the file COLORS.MEM is deleted.

Set Printer Margins

This option allows you to adjust the margins used when reports are printed. Different printers use different margins. Laser printers do not print on the first and last half-inch. The first line of laser printers (line 0) is in the location of the fourth line (line 3)

of other printers. The sixtieth line (line 59) is the last line of unadjusted laser printers; others use line 65.

The left margin setting will shift the printed text to the indicated number of columns to the right. Leaving the margin at 0 means the report will begin printing at the leftmost column. All reports use no more than 80 characters. This value must be taken into account when setting the left margin. If the printer used for reports uses 8.5-inch wide paper with 10 characters per inch, the largest left margin (without causing the printer to wrap printed lines to the next line) is 5. If the printer is capable of 12 characters per inch (102 characters per line), the left margin could be set to 11 (11 spaces before printing) and still have a right margin space of 11 spaces. The left margin can be set to allow a space for punching holes for notebooks.

When the screen is displayed after this option is selected, as shown in Figure 108, enter the desired numbers for margins. Enter A at the option prompt to accept new values or enter C to change values again. If you do not want the new values, enter Q to abandon them.

```
                    Printer margin setup routine      09/01/89
This routine allows you to set the margins for the printer to accommodate its setup (within limits).

Top margin (first line printed on) . . . .
(varies from 0 to bottom margin-20)

Bottom margin (last line printed on) . . .   56
(varies from top margin+20 to 65 on normal printers)

Left margin (first column printed on) . .    8
(varies from 0 to 20 or more, depending on paper width)


Accept (save values) / Change / Quit (without saving changes)


Enter option (A/C/Q)   « »
```

Figure 108. Printer margin setup display.

Reindex Files

Select this option when the files need to be reindexed. If the files are not present, they will be created at the beginning of program operation. The need for reindexing occurs when the program displays a message that an index file is corrupted just before a

program stops. You need to restart the program and select this option to fix the structure of the index files.

Because reindexing all the files can take some time, the program gives you a chance to confirm that reindexing is to proceed. The screen does not change from the menu except for the addition of the line asking whether indexing is to occur. Answering "N" returns you to the menu. Answering "Y" lets the program continue with the reindexing process.

Rebuild Case List File From Present Files

This option is selected to update the list of cases from those files currently on the disk. It is useful when new files have been copied onto the disk, and when files have been deleted manually (using any method other than the deleting option).

When this option is run, the program first deletes the current list so entries that had no file are eliminated. Then the program looks at all database files in the directory. If it has the right structure and has a first record with a structure that is identifiable as the one used by the program, the file will be added to the list of cases. The program automatically skips the two files that have the correct structure but are not case files. COALCASE.DBF is the file with the original structure that is duplicated for each case file. QWERTY.DBF is a temporary output file that is used by the cost model output routines. These two files cannot be case files and are not shown for that reason.

The last line of the display is used to inform you of the file being observed and whether it is or is not an identifiable case.

When the program completes its operation, only current, legitimate case files are in the list.

Metric Conversion Table

1 in.	=	25.4 mm
1 ft	=	0.305 m
1 sq ft	=	0.093 m^2
1 cu yd	=	0.076 m^3
1 lb	=	0.453 kg
1 gal	=	3.78 L
1 psi	=	6.89 kPa
°F	=	(°C × 1.8) +32
1 ton (short)	=	907.2kg

References

Code of Federal Regulations (CFR), title 10, part 436, "Guidelines Applicable to Federal Agency In-House Energy Management Programs," subpart A, "Life Cycle Cost Methods and Procedures."

Comprehensive Guide for Least-Cost Energy Decisions, National Bureau of Standards (NBS) Special Publication 709 (U.S. Department of Commerce, January 1987).

Energy Prices and Discount Factors for Life Cycle Cost Analysis, annual supplement to National Institute of Standards and Technology (NIST) Handbook 135 and NBS Special Publication 709 (U.S. Department of Commerce).

Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135 (U.S. Department of Commerce, 1987, under revision).

Appendix A: Sample Screening Model Output

```
*****************************************************************************
** Central Heating Plant Economics Evaluation Program          Page 1      **
** File: FCBGCG      Type: Cogeneration new plant (CG)         01/04/93    **
**    Desc: FORT CAMPBELL                                                  **
**    Tech: Gas / Oil Fired Boiler                                         **
*****************************************************************************

State    : KY - Kentucky
Location :  36d  7m -  86d 41m
County   :
Emission regulation region
#  0 -  State and federal only

Annual heating degree days:  4166

************************** Boiler Characteristics **************************
```

Type of heating system : Steam

Average Monthly Steam Flows (million Btu/hr)

Jan	Feb	Mar	Apr	May	Jun
133	122	106	79	49	50
Jul	Aug	Sep	Oct	Nov	Dec
46	44	52	61	95	148

Calculated PMCR: 267 thousand lb/hr steam

Average Monthly Electrical Loads (kW)

Jan	Feb	Mar	Apr	May	Jun
28580	27140	21790	24090	22220	25950
Jul	Aug	Sep	Oct	Nov	Dec
28740	31010	34380	22970	22880	23480

Peak Monthly Electrical Loads (kW)

Jan	Feb	Mar	Apr	May	Jun
37010	32430	31370	30730	30620	39540
Jul	Aug	Sep	Oct	Nov	Dec
46380	44150	45970	41320	29940	33380

Maximum peak monthly electrical load: 46380 kW

Cogeneration efficiency: 30%
Steam required for peak: 401,495 lb/hr
Plant cannot meet steam requirements for peak

Boiler technology: Gas / Oil Fired Boiler

Boiler sizes (thousand lb steam/hr) :
1: 89   2: 89   3: 89

```
******************************************************************************
**   Central Heating Plant Economics Evaluation Program            Page 2    **
**   File: FCBGCG       Type: Cogeneration new plant (CG)          01/04/93  **
**   Desc: FORT CAMPBELL                                                     **
**   Tech: Gas / Oil Fired Boiler                                            **
******************************************************************************


Natural gas composition - volume basis
    82.90 % Methane        0.00 % Ethylene      14.90 % Ethane
     0.00 % Propane        0.00 % Butane         0.00 % Hydrogen
     2.20 % Nitrogen       0.00 % Oxygen         0.00 % Hydrogen Sulfide (H2S)
     0.00 % Carbon Monoxide (CO)                 0.00 % Carbon Dioxide (CO2)
     1107 Btu/SCF Heating Value

Natural gas composition - weight basis
    73.70 % Carbon     22.94 % Hydrogen             0.00 % Oxygen
     0.00 % Sulfur      0.00 % Carbon Monoxide      3.36 % Inert gases (N2, CO2)
     22695 Btu/lb heating value

Boiler Operating Parameters -- Natural Gas
   Combustion air temp:  70 deg F     30 % relative humidity
   Flue gas temp: 350 deg F         1.00 % oxygen (dry basis)
   50.02 % combustibles
   11.39 % CO2                     87.59 % N2
   0.00481 lb/lb dry air           0.00772 mole/mole dry air
     4.45 % excess air             0.020 % combustibles

Boiler Performance -- Natural Gas
   Sensible dry gas loss:      4.853 %    Loss H2O vapor in air:      0.040 %
   Fuel H2O heat loss:         0.000 %    H2 comb H2O heat loss:     10.741 %
   Radiation heat loss:        0.156 %    Unaccounted for loss:       1.000 %
   Combustible gas heat loss:  0.058 %
   Boiler efficiency:         83.152 %

Fuel Oil #2 composition - weight basis
    87.40 % Carbon     12.50 % Hydrogen             0.00 % Oxygen
     0.00 % Nitrogen    0.10 % Sulfur               0.00 % Ash
     0.00 % Moisture
     18993 Btu/lb heating value
   0.856 Specific gravity

Boiler Operating Parameters -- Fuel Oil #2
   Combustion air temp:  70 deg F     30 % relative humidity
   Flue gas temp: 350 deg F         1.50 % oxygen (dry basis)
   80.02 % combustibles
   14.43 % CO2                     84.05 % N2
   0.00481 lb/lb dry air           0.00772 mole/mole dry air
     7.18 % excess air             0.020 % combustibles

Boiler Performance -- Fuel Oil #2
   Sensible dry gas loss:      5.492 %    Loss H2O vapor in air:      0.046 %
   Fuel H2O heat loss:         0.000 %    H2 comb H2O heat loss:      6.993 %
   Radiation heat loss:        0.156 %    Unaccounted for loss:       1.000 %
   Combustible gas heat loss:  0.064 %
   Boiler efficiency:         86.249 %
```

```
****************************************************************************
**   Coal Fired Boiler Evaluation Program                         Page 3   **
**   File: FCBGCG       Type: Cogeneration new plant (CG)        01/04/93   **
**   Desc: FORT CAMPBELL                                                    **
**   Tech: Gas / Oil Fired Boiler                                           **
****************************************************************************

************************* Boiler Performance @ PMCR *************************
Blowdown   :   5 %

Temperature out of stack :   350 deg F
Steam pressure           :  600 psig
Steam temperature        :  750 deg F        enthalpy  : 1378.9 Btu/lb
Condensate return temp   :  150 deg F        enthalpy  :  118.0 Btu/lb
Makeup water temperature :   50 deg F        enthalpy  :   18.0 Btu/lb
Inlet water temperature  :   97 deg F        enthalpy  :   64.7 Btu/lb

********************* Area and Water Requirements @ PMCR ********************

Building size : 12000 sq ft           Condensate Return     :    50 %
Plant area    :  2.21 acres           Boiler house leakage :     2 %
Plant height  :    40 ft              Water requirements    :   350 gpm (est)
Stack height  :    60 ft              Railway track length :   250 ft
Sewer dischrg :    75 gpm (est)
```

```
*****************************************************************************
**   Coal Fired Boiler Evaluation Program                        Page 4     **
**   File: FCBGCG      Type: Cogeneration new plant (CG)         01/04/93   **
**   Desc: FORT CAMPBELL                                                    **
**   Tech: Gas / Oil Fired Boiler                                           **
*****************************************************************************
```

*********************** General Site Considerations ***********************

Development and Construction

Contractors ARE AVAILABLE for CHP construction near the base. The availability of contractors in the neighborhood of the base will ensure the overall cost of the facility will be kept at a minimum.
  Score: 5

Asbestos MAY BE PRESENT around the pipelines for the CHP. Pipelines which have asbestos will have to be handled by special work crews. The asbestos will have to be disposed of properly, in special sites. The potential for this could introduce an additional expense not considered within the CHPEcon cost model. The presence or absence must be confirmed before continuing.
  Score: 2

The site IS CAPABLE of supporting the building and equipment foundation. No additional costs would be incurred for the construction of a CHP.
  Score: 5

The site MAY REQUIRE special cleanup (e.g., soil remediation, waste removal) before being suitable for construction. The state of the site should be verified to ensure that the facility can be built without special cleanup. Otherwise, additional costs would be incurred for the construction of a CHP that are not covered within the CHPEcon cost model.
  Score: 2

The site IS ACCESSIBLE by construction personnel and equipment. No special arrangements are required.
  Score: 5

The soil MAY NOT MEET THE REQUIREMENTS for minimizing wastewater seepage. This must be confirmed because more expensive control measures can be put into place, but their costs are not considered in the CHPEcon cost model.
  Score: 2

There IS SUFFICIENT LEVEL GROUND for the CHP facility. No additional costs are expected in this area.
  Score: 5

There IS ADEQUATE UTILITY ACCESS for the CHP facility connections. No additional costs are expected in this area.
  Score: 5

```
*****************************************************************************
**   Central Heating Plant Economics Evaluation Program          Page 5    **
**   File: FCBGCG       Type: Cogeneration new plant (CG)        01/04/93  **
**   Desc: FORT CAMPBELL                                                    **
**   Tech: Gas / Oil Fired Boiler                                           **
*****************************************************************************
```

There MAY BE TERRAIN (UNDERGROUND) CONSIDERATIONS for the CHP facility. This should be verified because the additional costs for removing and/or working around obstacles are not considered in the CHPEcon cost model.
Score: 2

There IS SUFFICIENT CONSTRUCTION STORAGE AREA for wastes from the CHP facility. No additional costs are expected in this area.
Score: 5

The site IS FREE OF INFRASTRUCTURE CONSTRAINTS. No additional costs are expected in this area.
Score: 5

There MAY BE OTHER CONSTRUCTION INTERFERING WITH CHP facility construction. This should be verified because any additional costs for working around or integrating the CHP construction with the other activity is not considered in the CHPEcon cost model.
Score: 2

There ARE STAFF AVAILABLE FOR COORDINATION of construction activities. No additional costs are expected in this area.
Score: 5

There IS NOT A PROBLEM (OR POTENTIAL) WITH FLOODING. No additional costs are expected in this area.
Score: 5

There ARE ADEQUATE STORAGE SITES for accepting material removed during construction. No additional costs are expected in this area.
Score: 5

The site IS LOCATED in a stable region. No problems can be expected with regard to earthquakes or other seismic disturbances to buildings or foundations.
Score: 5

There MAY BE ASBESTOS present. This should be verified because the additional cost required for removal of asbestos by licensed waste removers or working around the area is not included in the CHPEcon cost model.
Score: 2

Conditions DO NOT DIFFER materially from conditions ordinarily encountered. No additional costs are expected in this area.
Score: 5

```
*******************************************************************************
**   Central Heating Plant Economics Evaluation Program            Page 6    **
**   File: FCBGCG       Type: Cogeneration new plant (CG)          01/04/93   **
**   Desc: FORT CAMPBELL                                                      **
**   Tech: Gas / Oil Fired Boiler                                             **
*******************************************************************************
```

Adequate sources of construction material ARE AVAILABLE. No additional costs are expected in this area.
  Score: 5

There MAY BE REGULATIONS that will affect zoning. This should be verified because the additional cost related to zoning problems are not considered in the CHPEcon cost model.
  Score: 2

STAFF ARE AVAILABLE to supervise construction. No additional costs are expected in this area.
  Score: 5

There IS NO REMOVAL SCHEDULE that relies upon CHP construction. No additional costs are expected in this area.
  Score: 5

Total: 472/ 595 79%

===

Fuel Supply and Site Access

A DOMESTIC OR CANADIAN PRODUCER OR MARKETER CONTRACT for gas purchase is possible. Contracts with the source help to ensure adequate delivery of natural gas.
  Score: 5

A LONG-TERM OIL TRANSPORT CONTRACT WITH EXISTING OIL PIPELINE OWNER can be established. A contract closest to the primary source is potentially the least cost option and the most stable in operation.
  Score: 5

There ARE NO SPECIAL SETUPS required for site access. No additional costs are expected in this area.
  Score: 5

Total: 120/ 120 100%

===

Ecology

```
******************************************************************************
**   Central Heating Plant Economics Evaluation Program          Page 7    **
**   File: FCBGCG        Type: Cogeneration new plant (CG)      01/04/93   **
**   Desc: FORT CAMPBELL                                                   **
**   Tech: Gas / Oil Fired Boiler                                          **
******************************************************************************
```

Endangered species ARE NOT PRESENT on the site. No additional costs are expected in this area.
  Score: 5

There MAY BE POTENTIAL for local resident opposition. This should be verified because the additional costs for overcoming local resident opposition are not considered in the CHPEcon cost model.
  Score: 2

The facility IS NOT LOCATED near areas sensitive to acid rain. No additional costs are expected in this area (in the absence of new air emissions regulations).
  Score: 5

There MAY BE A POTENTIAL IMPACT from soil / shore erosion. This should be verified because the additional costs required to prevent erosion are not considered in the CHPEcon cost model.
  Score: 2

There area IS NOT PART of a protected wetlands. No additional costs are expected in this area.
  Score: 5

Total: 164/ 215 76%

==

Social Considerations

There ARE NOT SITES of significance nearby. No additional costs are expected in this area.
  Score: 5

There ARE NO SPECIAL SITES nearby that would interfere with the CHP. No additional costs are expected in this area.
  Score: 5

Water contamination IS NOT A MAJOR ISSUE in the community. No additional costs are expected in this area.
  Score: 5

There ARE NO REGULATIONS concerning ambient noise. The additional costs to reduce or overcome noise limitations are not considered in the CHPEcon cost model.
  Score: 5

```
*****************************************************************************
**   Central Heating Plant Economics Evaluation Program          Page 8    **
**   File: FCBGCG       Type: Cogeneration new plant (CG)       01/04/93   **
**   Desc: FORT CAMPBELL                                                    **
**   Tech: Gas / Oil Fired Boiler                                           **
*****************************************************************************
```

There ARE NO NEIGHBORS that limit CHP placement. No additional costs are expected in this area.
Score: 5

Sufficient room IS AVAILABLE to insure compliance with noise regulations. No additional costs are expected in this area.
Score: 5

The area planned for the CHP IS NOT A CULTURAL RESOURCE. No additional costs are expected in this area.
Score: 5

Construction projects HAVE BEEN SUCCESSFUL. No additional costs are expected in this area.
Score: 5

The community economic situation IS CONDUCIVE to the start of a large construction project offering local jobs. No additional costs are expected in this area.
Score: 5

Total: 305/ 305 100%

===

Facility Services

Condition of system is fair
Additional costs may be required to install a new distribution system. These costs are not considered in the detailed evaluation program.
Score: 3

Steam distribution system routing is medium
It may be difficult to incorporate the existing distribution system into the new plant. Additional costs may be required heavily modify the existing distribution system. These costs are not considered in the new plant detailed evaluation section of this program.
Score: 2

City water available: Yes
Score: 5

There IS DIRECT ACCESS to transmission lines for the delivery of electricity to the CHP. No additional costs are expected in this area.
Score: 5

```
******************************************************************************
**   Central Heating Plant Economics Evaluation Program              Page 9   **
**   File: FCBGCG       Type: Cogeneration new plant (CG)          01/04/93   **
**   Desc: FORT CAMPBELL                                                      **
**   Tech: Gas / Oil Fired Boiler                                             **
******************************************************************************
```

There IS TRAINED STAFF available for instrumentation calibration and maintenance of the proposed CHP. No additional costs are expected in this area.
  Score: 5

The existing facility's distribution system WILL BE ABLE TO UTILIZE the new CHP steam output without modification. No additional costs are expected in this area.
  Score: 5

There IS ADEQUATE TRAFFIC CONTROL supplied by the existing facilities. No additional costs are expected in this area.
  Score: 5

The current staff IS UTILIZING WRITTEN procedures and operating the existing facility in such a fashion that the addition of the proposed CHP will be incorporated smoothly. No additional costs are expected in this area.
  Score: 5

Total: 205/ 255 80%

==

Waste Handling and Emissions

There MAY BE ONE OR MORE OUTSIDE AGENCIES with sites that are or can be used for landfill of the collected ash. This should be verified because the additional costs for transporting the ash or purchasing and maintaining a landfill site are not considered in the CHPEcon cost model.
  Score: 2

Local sewer system available: Yes
  Score: 5

Ash and other discharges from the CHP WILL NOT BE classified as hazardous wastes. No additional costs are expected in this area.
  Score: 5

Blowdown water and other wastewater CAN BE DELIVERED DIRECTLY to a sewer system. No additional costs are expected in this area.
  Score: 5

```
******************************************************************************
**   Central Heating Plant Economics Evaluation Program            Page 10    **
**   File: FCBGCG       Type: Cogeneration new plant (CG)          01/04/93   **
**   Desc: FORT CAMPBELL                                                      **
**   Tech: Gas / Oil Fired Boiler                                             **
******************************************************************************
```

Other pollutant-emitting plants MAY BE PRESENT in the surrounding vicinity. This should be verified because the additional costs for complying with NAAQ standards and PSD programs are not considered in the CHPEcon cost model.
  Score: 2

There MAY BE A POSSIBILITY for generating air emissions credits. This should be verified because this represents a potential revenue gain for the facility that is not considered in the CHPEcon cost model.
  Score: 2

There ARE LOCAL REGULATIONS regarding waste handling and disposal. The additional costs for handling and disposing of waste created by these regulations are not considered in the CHPEcon cost model.
  Score: 0

     Total: 176/ 255 69%

==

Military

The base HAS SECURE ACCESS to fuel supplies. No additional costs are expected in this area.
  Score: 5

Outside contractor operations WILL AFFECT base security. The additional costs for enhancing base security are not considered in the CHPEcon cost model.
  Score: 0

Construction WILL AFFECT base security. The additional costs for ensuring base security during construction are not considered in the CHPEcon cost model.
  Score: 0

A change in base mission is NOT LIKELY. No additional costs are expected in this area.
  Score: 5

Current base activities WILL INTERFERE with plant construction. The additional costs for construction delays or rescheduling are not considered in the CHPEcon cost model.
  Score: 0

```
******************************************************************************
**   Central Heating Plant Economics Evaluation Program          Page 11    **
**   File: FCBGCG       Type: Cogeneration new plant (CG)        01/04/93   **
**   Desc: FORT CAMPBELL                                                    **
**   Tech: Gas / Oil Fired Boiler                                           **
******************************************************************************
```

Total: 90/ 200 45%

==

Cogeneration

Plant will be operated from 4000 hours through 6000 hours per year
The facility may not be operating enough to justify building a cogeneration plant.
Score: 3

The existing electricity distribution system MAY BE compatible with a cogeneration system
Cogeneration may not be feasible because of the additional electrical distribution costs that will be necessary in rewiring the power lines.
Score: 2

It IS NOT likely that energy demand will be curtailed
Score: 5

The utility WILL maintain and repair interconnection facilities
Score: 5

The utility WILL be cooperative in setting up the electrical interconnections and standby power costs
Score: 5

The electric utility DOES use coal as their primary fuel
Cogeneration may not be cost effective due to the local availability of relativaly low cost electricity generated by coal.
Score: 1

The facility's average electrical power / steam ratio is above 75 kWh/MBtu
Cogeneration may not be cost effective because a significant portion of the base's electric requirements must still be purchased from the local utility. A more detailed analysis of the electrical and thermal load curves should be performed prior to a detailed evavuation.
Score: 5

An adequate sink IS PRESENT at the facility. No additional costs are expected in this area.
Score: 5

Cost of electricity: 4.70 cents/kWh Cost of coal: 2.50 $/Mbtu
The high cost of fuel may make cogeneration prohibitive.

```
*****************************************************************************
**   Central Heating Plant Economics Evaluation Program            Page 12    **
**   File: FCBGCG       Type: Cogeneration new plant (CG)          01/04/93   **
**   Desc: FORT CAMPBELL                                                      **
**   Tech: Gas / Oil Fired Boiler                                             **
*****************************************************************************

The facility's electric load is between 25 MW and 50 MW
The facility's electric load maybe sufficient to warrent cogeneration.
A more detailed evaluation of the electrical and thermal load curves
should be performed.
  Score:   3

The facility's load factor is above 40%
The load factor is sufficient to warrant cogeneration.
  Score:   5

The facility's annual electrical power / steam ratio is above 75 kWh/MBtu
Cogeneration may not be cost effective because a significant portion
of the base's electric requirements must still be purchased from
the local utility.  A more detailed analysis of the electrical and
thermal load curves should be performed prior to a detailed evavuation.
  Score:   5

PMCR is below 400 MMBtu output; facility may not be suitable for cogeneration

     Total:   455/  585      77%

=============================================================================
```

```
******************************************************************************
**   Central Heating Plant Economics Evaluation Program          Page 13    **
**   File: FCBGCG       Type: Cogeneration new plant (CG)        01/04/93   **
**   Desc: FORT CAMPBELL                                                    **
**   Tech: Gas / Oil Fired Boiler                                           **
******************************************************************************
```

General Questions Summary

	Total	Max	Rating
Development and Construction	472	595	79
Fuel Supply and Site Access	120	120	100
Ecology	164	215	76
Social Considerations	305	305	100
Facility Services	205	255	80
Waste Handling and Emissions	176	255	69
Military	90	200	45
Cogeneration	455	585	77

Boiler technology rating: 10

Feasibility score: 10/10 = 100%

INVENTORY file data used for thermal input specification

Installation plant: BLDG 7008 data year: 1990

Installation plant: BLDG 7223 data year: 1990

Installation plant: BLDG 650 data year: 1990

Installation plant: BLDG 3902 data year: 1990

Installation plant: BLDG 157 data year: 1990

Installation plant: BLDG 858 data year: 1990

INVENTORY file data used for electrical input specification

Installation data year: 1990

Appendix B: Sample Cost Model Output

B.1 Long Form

```
 Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 1
File: FCBGCG       Type: Cogeneration new plant (CG)                    01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Base Information
******************************************************************************

State: KY - Kentucky               Base DOE Region: 3
PMCR: 267,000 lb/hr steam      Number of boilers: 3

Steam Properties:  600 psi   (1378.9 Btu/lb)
Inlet water temp:  97 deg F      enthalpy:   64.7 Btu/lb


******************************************************************************
   Boiler Design Parameters
******************************************************************************

A mixed bed for condensate polishing IS REQUIRED
A dealkalizer unit IS INCLUDED

******************************************************************************
   Cogeneration Subsystem Design Parameters
******************************************************************************

Average Steam Loads (1000 lb/hr)
               Jan      Feb      Mar      Apr      May      Jun
Heat/Proc:     134*     123*     107*      80*      49*      50*
Cogen Sys:     226      230      188      209      193      199
               Jul      Aug      Sep      Oct      Nov      Dec
Heat/Proc:      47*      44*      53*      62*      96*     148*
Cogen Sys:     203      225      244      172      199      196
Cogeneration efficiency: 30%
Cogen system sized for 402,000 lb steam/hr
```

```
Central Heating Plant Economics Evaluation Program -- Cost Analysis       Page 2
File: FCBGCG        Type: Cogeneration new plant (CG)                     01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Plant Design Parameters --- Space Requirements
******************************************************************************

Height of the plant: 40 ft
Building area: 12000 sq ft
Plant area: 2.21 acres

******************************************************************************
   Plant Design Parameters --- Water & Water Treatment Specifications
******************************************************************************

Feedwater flow: 561 gpm
Surface area of feedwater heater: 0 sq ft
Number of deaerators: 1
Number of resin vessels / train: 2
Number of mixed beds / train: 1
Boiler 1: 1 motor-driven feedwater pump -- 171 gpm
Boiler 2: 1 motor-driven feedwater pump -- 171 gpm
Boiler 3: 1 motor-driven feedwater pump -- 171 gpm
Number of condensate transfer pumps: 3
Condensate transfer pump size: 2116 gpm

Condensate storage tank size: 8550 gallons
Number of long term oil storage tanks: 2
Capacity of one long term oil storage tank: 919500 gal
Number of oil (day storage) pumps: 3
Short term storage tank size: 10,209 gallons

Length of rail track: 250 ft
Annual personnel water use: 102,287 gallons
```

```
 Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 3
File: FCBGCG        Type: Cogeneration new plant (CG)                    01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Facility Capital Costs
******************************************************************************

Boiler capital costs: $ 2,459,955
  Boiler #1 ( 89 k-lb stm/hr) cost: $ 819,985
  Boiler #2 ( 89 k-lb stm/hr) cost: $ 819,985
  Boiler #3 ( 89 k-lb stm/hr) cost: $ 819,985

Stack capital costs: $ 34,709

Building and service capital costs: $ 1,891,131
  Boiler house capital costs: $ 1,652,825
  Miscellaneous building costs: $ 238,305

Cogeneration equipment capital costs: $ 5,652,931
  Cooling tower and condenser not required.  Heating uses all steam.
  Cost of feedwater heater: $ 12,901
  Cost of turbine generator: $ 5,640,029

Boiler Water Treatment System Capital Costs: $ 1,230,821
  Cost of demineralizers: $ 821,605
  Cost of mixed bed for condensate polishing: $ 292,954
  Cost of chemical injection skid: $ 33,056
  Cost of water lab: $ 44,075
  Cost of 1 deaerator: $ 39,129

Cost of boiler feedwater pumps: $ 140,434
Cost of condensate transfer pumps: $ 36,003

Cost of condensate storage tank: $ 9,166
Cost of long term oil storage: $ 431,737
  Cost of long term storage tanks: $ 363,749
  Cost of long term storage-other: $ 67,987

Cost of oil (day storage) pumps: $ 8,594
Cost of oil (day storage) heaters: $ 10,137
Cost of short term storage tanks: $ 26,629

Cost of oil unloading pumps: $ 14,544
Cost of [3] oil transfer pumps: $ 7,768
Cost of fire protection equipment: $ 55,094
Cost of 1 continuous blowdown tank: $ 1,286
Cost of 1 intermittent blowdown tank: $ 1,286
Compressor cost (2 - 30 Hp - 150 psig): $ 27,196

Cost of car puller and accessories: $ 22,037
Cost of rail tracks: $ 23,415

Site preparation cost: $ 6,087
Site improvement cost: $ 257,289

Total cost of mobile equipment: $ 42,973
```

```
Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 4
File: FCBGCG       Type: Cogeneration new plant (CG)                   01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Facility Capital Costs, cont
******************************************************************************

  Cost of fork lift: $ 22,037
  Cost of pickup truck: $ 15,426
  Cost of power sweeper: $ 5,509

Cost of electric substation: $ 109,887
Electrical costs: $ 277,846

Piping costs: $ 1,574,464

Instrumentation costs: $ 582,155

Spare parts cost: $ 39,952

Initial consumables: $ 13,983

Tools cost: $ 28,648
```

```
Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 5
File: FCBGCG       Type: Cogeneration new plant (CG)                   01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Direct Costs
******************************************************************************

Direct costs: $ 5,570,526
  Development permit cost: $ 99,880
  Project contingency costs: $ 1,918,183
  Construction management costs: $ 895,152
  Engineering and design costs: $ 1,534,546
  Owner management costs: $ 767,273
  Startup cost: $ 355,491

******************************************************************************
   Installed Capital Equipment Cost Summary
******************************************************************************

Total Capital Costs: $ 13,413,016
Total Direct labor cost: $ 2,628,471
Total Freight cost: $ 328,067
Total Bulk material cost: $ 2,733,894
Total Direct costs: $ 5,570,526

Plant installed cost: $ 24,673,976
```

```
Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 6
File: FCBGCG       Type: Cogeneration new plant (CG)                   01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Facility Operating Labor Requirements
******************************************************************************

Operation personnel requirements
     plant manager: 1
     plant engineer: 0
     plant technician: 0
     plant clerk: 0
     plant secretary: 0
     plant janitor: 0
     operations operator: 4
     operations assistant operator: 1
     maintenance a mechanic: 1
     maintenance a electrician: 1
     maintenance laborer: 1

Operating staff: 12

Annual Labor Costs: $ 577,231
```

```
 Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 7
File: FCBGCG      Type: Cogeneration new plant (CG)                      01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Yearly O & M Costs Summary
******************************************************************************

Annual boiler maintenance costs: $ 17,219
Annual insurance cost: $ 546,778
Maximum electrical consumption @ PMCR: 647 kW
  Annual electricity usage: 1,958,129 kW-hr
Annual O & M (materials/supplies) costs: $ 249,616
  Annual condensate make-up water cost: $ 129,798
  Annual blowdown make-up water cost: $ 12,979
  Annual facility washdown water cost: $ 2,340
  Annual personnel water cost: $ 306
  Annual condensate polisher water cost: $ 6,023
  Annual demineralizer water cost: $ 15,682
  Annual mixed bed water cost: $ 6,023
  Annual chemicals cost: $ 71,893
  Annual sanitary sewer cost: $ 4,568
Annual miscellaneous maintenance costs: $ 16,969
Study year water cost: $3.00/1000 gallon
1993 cost for distillate:  0.633 $/gallon
1993 cost for residual:  0.410 $/gallon
1993 cost for natural gas:  2.550 $/million Btu
1993 cost for electricity:  0.047 $/kW-hr
  Annual consumables cost: $ 2,796
  Annual spare parts cost: $ 5,992
  Annual mobile equipment maintenance: $ 3,437
1997 Natural gas costs  : $    3,276,314
1997 Auxiliary Energy Costs       : $        94,177
1997 #2 fuel oil costs  : $    5,838,591


  Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 8
File: FCBGCG      Type: Cogeneration new plant (CG)                      01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Periodic Maintenance Costs Summary
******************************************************************************

Major boiler maintenance costs (every 15 years): $ 147,597
Major stack maintenance costs (every 10 years): $ 6,941
Major cooling tower maintenance costs (every 15 years): $ 0
Turbine generator maintenance costs (every 5 years): $ 592,203
Major water treatment system maintenance costs (every 10 years): $ 501,551
Major deaerator maintenance costs (every 20 years): $ 9,782
Motor-driven feedwater pumps maint costs (every 15 years): $ 56,173
Centrifugal pump maint costs (every 18 years): $ 14,401
Circulation water pump maintenance costs (every 25 years): $ 7,619
Sump pump maintenance costs (every 20 years): $ 6,016
Oil pump maintenance costs (every 5 years): $ 7,473
Periodic EPA permit testing/renewal costs (every 3 years): $ 30,000
```

```
Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 9
File: FCBGCG       Type: Cogeneration new plant (CG)                    01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

****************************************************************************
   Economic Data Summary
****************************************************************************

Capital Equipment Escalation Factor:  1.102
     based on Engineering News Record, Construction Cost Index: 5032.16

Non-Labor Operation & Maintenance Escalation Factor:  1.092
     based on Chemical Engineering, M & S Index, Steam Power Comp:  935.60

Operation & Maintenance Labor Escalation Factor:  1.119
     based on Engineering News Record, Skilled Labor Index: 4626.82

Construction Labor Escalation Factor:  1.024
     based on Chemical Engineering, Construction Labor Index:  271.10

Annual Facility Output: 722,309 thousand lb steam
                        722,309 thousand lb steam (incl cogen)
Steam enthalpy:         1378.9 Btu/lb
Inlet enthalpy:           64.7 Btu/lb
Annual Natural Gas Usage: 1,031 10^6 SCF
Heating plant efficiency: 83.2% natural gas
Discount Rate: 4 %
Cogeneration Electricity Credit Basis: 83,439,707 kW-hr
Year of Study: 1993
Years of Operation: 1997 - 2021
10% Investment Cost Exclusion IS NOT applied
Annual #2 Fuel Oil Usage: 8,111 10^3 gal
Heating plant efficiency: 86.2% #2 fuel oil
```

```
 Central Heating Plant Economics Evaluation Program -- Cost Analysis     Page 10
File: FCBGCG        Type: Cogeneration new plant (CG)                     01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

****************************************************************************
   Cash Flow Summary
****************************************************************************

Analysis using natural gas as primary fuel
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
1996 adjusted investment:  24,673,976    existing plant salvage:          0
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Year	Boiler Fuel	Auxiliary Energy	Non-Energy O&M	Repair and Replacement	Cogen Elec Credit
1997	3,276,314	94,177	873,265	0	4,013,086
1998	3,424,725	94,914	901,231	0	4,044,484
1999	3,653,027	95,786	901,231	30,000	4,081,629
2000	3,881,356	97,930	901,231	0	4,173,012
2001	4,098,258	99,204	901,231	599,676	4,227,286
2002	4,337,990	100,410	901,231	30,000	4,278,707
2003	4,566,294	101,550	901,231	0	4,327,270
2004	4,760,366	102,623	901,231	0	4,372,984
2005	4,988,668	104,098	901,231	30,000	4,435,823
2006	5,137,081	104,500	901,231	1,108,170	4,452,950
2007	5,331,150	105,303	901,231	0	4,487,202
2008	5,513,790	105,840	901,231	30,000	4,510,078
2009	5,799,183	106,443	901,231	0	4,535,767
2010	6,061,771	107,315	901,231	0	4,572,915
2011	6,170,652	107,970	901,231	833,447	4,600,824
2012	6,279,533	108,632	901,231	0	4,629,055
2013	6,388,439	109,302	901,231	0	4,657,597
2014	6,497,317	109,979	901,231	44,401	4,686,460
2015	6,606,225	110,665	901,231	0	4,715,676
2016	6,715,109	111,358	901,231	1,123,968	4,745,215
2017	6,824,015	112,059	901,231	30,000	4,775,067
2018	6,914,754	112,719	901,231	0	4,803,178
2019	7,005,489	113,387	901,231	0	4,831,641
2020	7,096,259	114,063	901,231	30,000	4,860,462
2021	7,186,999	114,749	901,231	607,296	4,889,683

```
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
2022 new plant salvage:          0
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -


  Central Heating Plant Economics Evaluation Program -- Cost Analysis     Page 11
File: FCBGCG        Type: Cogeneration new plant (CG)                     01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

****************************************************************************
   Life Cycle Cost Summary
****************************************************************************

Analysis using natural gas as primary fuel
+ PV 'Adjusted' Investment Costs                          = $  21,935,075
+ PV Energy + Transportation Costs                        = $  73,612,863
+ PV Annually Recurring O&M Costs                         = $  12,492,373
+ PV Non-Annually Recurring Repair & Replacement          = $   2,295,447
- PV Cogeneration Electricity Credit                      = $  61,609,476
+ PV Disposal Cost of Existing System                     = $           0
+ PV Disposal Cost of New/Retrofit Facility               = $           0

                                                           ----------------

Total Life Cycle Cost (1993)                              = $  48,726,282

Levelized Cost of Service (1997 start)               = 3.6635 $/MMBtu
Levelized Cost of Service (1997 start)               = 5.0516 $/1000 lb steam
```

Central Heating Plant Economics Evaluation Program -- Cost Analysis Page 12
File: FCBGCG Type: Cogeneration new plant (CG) 01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

****
Cash Flow Summary
****

Analysis using #2 fuel oil as primary fuel

1996 adjusted investment: 24,673,976 existing plant salvage: 0

Year	Boiler Fuel	Auxiliary Energy	Non-Energy O&M	Repair and Replacement	Cogen Elec Credit
1997	5,838,591	94,177	873,265	0	4,013,086
1998	6,069,467	94,914	901,231	0	4,044,484
1999	6,322,400	95,786	901,231	30,000	4,081,629
2000	6,575,283	97,930	901,231	0	4,173,012
2001	6,784,200	99,204	901,231	599,676	4,227,286
2002	6,971,104	100,410	901,231	30,000	4,278,707
2003	7,136,055	101,550	901,231	0	4,327,270
2004	7,278,990	102,623	901,231	0	4,372,984
2005	7,421,927	104,098	901,231	30,000	4,435,823
2006	7,542,905	104,500	901,231	1,108,170	4,452,950
2007	7,663,833	105,303	901,231	0	4,487,202
2008	7,784,760	105,840	901,231	30,000	4,510,078
2009	7,916,720	106,443	901,231	0	4,535,767
2010	8,004,706	107,315	901,231	0	4,572,915
2011	8,148,471	107,970	901,231	833,447	4,600,824
2012	8,292,291	108,632	901,231	0	4,629,055
2013	8,436,113	109,302	901,231	0	4,657,597
2014	8,579,881	109,979	901,231	44,401	4,686,460
2015	8,723,697	110,665	901,231	0	4,715,676
2016	8,867,464	111,358	901,231	1,123,968	4,745,215
2017	9,011,276	112,059	901,231	30,000	4,775,067
2018	9,131,117	112,719	901,231	0	4,803,178
2019	9,250,954	113,387	901,231	0	4,831,641
2020	9,370,791	114,063	901,231	30,000	4,860,462
2021	9,490,578	114,749	901,231	607,296	4,889,683

2022 new plant salvage: 0

Central Heating Plant Economics Evaluation Program -- Cost Analysis Page 13
File: FCBGCG Type: Cogeneration new plant (CG) 01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

****
Life Cycle Cost Summary
****

Analysis using #2 fuel oil as primary fuel

+ PV 'Adjusted' Investment Costs	= $ 21,935,075
+ PV Energy + Transportation Costs	= $ 106,617,598
+ PV Annually Recurring O&M Costs	= $ 12,492,373
+ PV Non-Annually Recurring Repair & Replacement	= $ 2,295,447

B.2 Short Form

```
 Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 1
File: FCBGCG         Type: Cogeneration new plant (CG)                    01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

****************************************************************************
   Base and Plant Information
****************************************************************************

State: KY - Kentucky                  Base DOE Region: 3
PMCR: 267,000 lb/hr steam         Number of boilers: 3

Height of the plant: 40 ft
Building area: 12000 sq ft
Plant area: 2.21 acres

****************************************************************************
   Facility Parameters
****************************************************************************

Capital Equipment Escalation Factor:  1.102 (5032.16/1993)
Non-Labor Operation & Maintenance Escalation Factor:  1.092 ( 935.60/1993)
Operation & Maintenance Labor Escalation Factor:  1.119 (4626.82/1993)
Construction Labor Escalation Factor:  1.024 ( 271.10/1993)

Annual electricity usage: 1,958,129 kW-hr

1993 cost for distillate:  0.633 $/gallon
1993 cost for residual:  0.410 $/gallon
1993 cost for natural gas:  2.550 $/million Btu
1993 cost for electricity:  0.047 $/kW-hr

Annual Facility Output: 722,309 thousand lb steam
                        722,309 thousand lb steam (incl cogen)
Annual Natural Gas Usage: 1,031 10^6 SCF
Heating plant efficiency: 83.2% natural gas
Year of Study: 1993
Years of Operation: 1997 - 2021
Annual #2 Fuel Oil Usage: 8,111 10^3 gal
Heating plant efficiency: 86.2% #2 fuel oil

****************************************************************************
   Facility Capital Costs
****************************************************************************
```

Equipment		Cost	Equipment		Cost
Boiler:	$	2,459,955	Stack:	$	34,709
Building/service:	$	1,891,131	Cogen Equipment:	$	5,652,931
Water trtmnt:	$	1,230,821	Feedwtr pmps:	$	140,434
Cond xfr pmps:	$	36,003	Cond strg tnk:	$	9,166
Oil (long) storage:	$	431,737	Oil day strg pmp:	$	8,594
Oil heaters:	$	10,137	Oil day strg tanks:	$	26,629
Oil unload pumps:	$	14,544	Oil xfr pmps:	$	7,768
Fire protection:	$	55,094	Cont bldn tnk:	$	1,286
Intr bldn tnk:	$	1,286	Compressor:	$	27,196
Car puller:	$	22,037	Rail:	$	23,415
Site preparation:	$	6,087	Site improvements:	$	257,289

```
Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 2
File: FCBGCG       Type: Cogeneration new plant (CG)                     01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

*****************************************************************************
   Facility Capital Costs, cont
*****************************************************************************

Mobile equipment:   $          42,973    Elec substation:     $        109,887
Electrical:         $         277,846    Piping:              $      1,574,464
Instrumentation:    $         582,155    Direct costs:        $      5,570,526
*****************************************************************
Plant installed cost:   $      24,673,976

*****************************************************************************
   Facility Annual O & M and Energy Costs
*****************************************************************************

Operating staff: 12
Annual Labor Costs: $ 577,231
Annual Year Non-Labor O & M Costs : $      901,231
1997 Natural gas costs  : $   3,276,314
1997 Auxiliary Energy Costs      : $       94,177
1997 #2 fuel oil costs  : $   5,838,591

*****************************************************************************
   Periodic Major Maintenance Cost Summary
*****************************************************************************

Time Interval          Cost             Time Interval          Cost
-----------------------------           -----------------------------
3 years            $    30,000          5 years            $   599,676
10 years           $   508,494          15 years           $   203,771
18 years           $    14,401          20 years           $    15,798
25 years           $     7,620

*****************************************************************************
   Facility Life Cycle Cost Summary
*****************************************************************************

Analysis using natural gas as primary fuel
+ PV 'Adjusted' Investment Costs                         = $  21,935,075
+ PV Energy + Transportation Costs                       = $  73,612,863
+ PV Annually Recurring O&M Costs                        = $  12,492,373
+ PV Non-Annually Recurring Repair & Replacement         = $   2,295,447
- PV Cogeneration Electricity Credit                     = $  61,609,476
+ PV Disposal Cost of Existing System                    = $            0
+ PV Disposal Cost of New/Retrofit Facility              = $            0
                                                         -----------------
Total Life Cycle Cost (1993)                             = $  48,726,282

Levelized Cost of Service (1997 start)              = 3.6635 $/MMBtu
Levelized Cost of Service (1997 start)              = 5.0516 $/1000 lb steam
```

```
 Central Heating Plant Economics Evaluation Program -- Cost Analysis      Page 3
File: FCBGCG       Type: Cogeneration new plant (CG)                     01/04/93
Desc: FORT CAMPBELL
Tech: Gas / Oil Fired Boiler

******************************************************************************
   Facility Life Cycle Cost Summary
******************************************************************************

Analysis using #2 fuel oil as primary fuel
+ PV 'Adjusted' Investment Costs                        = $  21,935,075
+ PV Energy + Transportation Costs                      = $ 106,617,598
+ PV Annually Recurring O&M Costs                       = $  12,492,373
+ PV Non-Annually Recurring Repair & Replacement        = $   2,295,447
- PV Cogeneration Electricity Credit                    = $  61,609,476
+ PV Disposal Cost of Existing System                   = $           0
+ PV Disposal Cost of New/Retrofit Facility             = $           0
                                                        -----------------
Total Life Cycle Cost (1993)                            = $  81,731,018

Levelized Cost of Service (1997 start)             = 6.1450 $/MMBtu
Levelized Cost of Service (1997 start)             = 8.4734 $/1000 lb steam
```

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